European Commission

ICT concepts for optimization of mobility in Smart Cities

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Executive Summary

The Smart 2011/0067 study was contracted by the European Commission to investigate Information and Communication Technology (ICT) concepts for optimization of mobility in Smart Cities. The consortium consisted of four partners: VTT (Finland), ISIS (Italy), POLIS (Belgium), and AustriaTech (Austria, coordinator).
The deployment of ICT mobility related services can help to address the challenge raised by urban transport. In this regard ITS will be of major importance in securing future sustainable mobility against a background of mounting economic, environmental, and societal pressure. The provision of information can encourage more sustainable urban mobility behavior and at the same time a more efficient use of existing resources (energy, infrastructure, and vehicles). ICT can enable the full integration of the urban mobility system, which means integrating collective and private modes of transport (including public and private vehicles). The integration of services of different kinds and sectors is enabled by ICT and allows for the emergence of Smart Cities. A Smart City uses data, information and communication technologies strategically to: provide more efficient, new or enhanced services to citizens; monitor and track government's progress toward policy outcomes, including meeting climate change mitigation and adaptation goals; manage and optimize the existing infrastructure, and plan for new more effectively; reduce organizational silos and employ new levels of cross-sector collaboration; and enable innovative business models for public and private sector service provision[1].
The main objective of the study was to perform an analysis on how ICT applications can contribute to the optimization of mobility within the recently emerging European Smart Cities. The study intended to define strategic research and innovation agendas, identify gaps between current ICT infrastructure and identified needs and describing the roles and responsibilities of partners for supporting fast ICT take-up.

At the beginning an analysis about the trends and policy changes in the urban mobility patterns that would require new ICT research and development to optimize/replace mobility has been carried out. Recent historical patterns from the past twenty years as well as influencing factors in future mobility trends in urban areas were identified and taken into consideration. The analysis of future trends affecting mobility in the European urban area aiming at identifying future challenges and potential ITS services and applications revealed three main challenges for the future: urban sprawl, population ageing and higher motorization rates. A fourth one, the future emergency of urban freight transport has also been mentioned, even if only scarce observations from some big cities (e.g. Barcelona, Paris) are available. A database with a sample of 44 European cities (15 big, 14 medium-big, 8 medium and 7 medium-small cities) has been set up to classify the cities according to the level of criticality of mobility patterns and vulnerability to future unsustainable paths. Five main indicators were selected and classified into three categories (low, medium, high) to address the structure of mobility (population density, car ownership, car density, availability of public transport) and the use of transport (modal shares). To develop the classification of the status of mobility, an indicator defined index of impact severity was introduced to take into account the effects of the dimensions, travel distances and population density coming from the motorized component of the modal share. On basis of a multi-component weighted combination of the database indicators and the index of impact severity the classification of cities in terms of level of criticality of the mobility status

[1] Source: ARUP and the Climate Group

has been carried out (high, medium, low and non-critical cities). The result of the classification led to the conclusion that large cities (big and medium-big) are in critical position in terms of sustainability of mobility patterns. The analysis of the Sustainable Urban Mobility Plans (SUMPs) for a sample of seven large cities has allowed to identify a list of transport policies, deemed to ensure a sustainable mobility in the future. The packages of policies and individual measures have been evaluated against their capability to address the "Key pillars of the sustainable urban mobility": more fluid, more accessible, safer, greener, and even smarter comprising the set of tools suitable to support the implementation, the monitoring and the enforcement of mobility policies. The role of ITS/ICT measures in each pillar has been identified and ITS applications were put in relationships to the main challenges on future mobility trends.

A review of state-of-the-art of advanced ICT based mobility services in urban areas has been carried out to establish an overview of the current level of deployment and use across Europe of ICT based services relevant for mobility in urban areas. This review consisted of a literature study as well as a questionnaire which has mainly been addressed to the 44 cities analyzed, but was also sent to a larger group of cities. The results of the survey conducted revealed some important obstacles to the establishment of a comprehensive overview of ITS applications across cities in Europe. The diversity of services and of entities responsible for service implementation and management makes it difficult to obtain a comprehensive overview, which does not exist as such in many cities. Responsibilities for ITS services are scattered among various local actors such as the traffic management department of the city, the transport authority, and the public transport operators. In addition, a significant number of mobility services in cities are provided by private operators, often supported by ICT, for instance for car sharing or bike sharing services. As a result, it was not rare to identify during this study some services which were even not known by most of the officials of a city. Moreover, the survey showed that the most common ITS applications are related to the management of the signalized network. A strong emphasis is set on priority of public transport, passengers' safety as well as the ease of using the public transport system (including services for handicapped people). In contrast, ITS applications related to Bike & Ride combination of modes, was found to be rather limited. The analysis of the legal and regulatory framework included the topics procurement, intellectual property, liability and privacy. Several issues like who is liable if the wrong information is given or potential invasion of privacy have to be addressed. Furthermore, ITS deployment challenges were analyzed, showing that the main challenges for deploying ITS are non-technical. The analysis showed that the organizational part (cross-boundary collaboration, operational matters etc.) is of high importance since a lot of parties from both the public and private sector are involved, but also the financing of ITS is one of the main barriers and has to be addressed. The analysis of the questionnaires provides an overview about the current developed ICT infrastructure and applications in various cities and points out their current gaps. The related analysis of the legal and regulatory framework and ITS deployment challenges indicates the future needs.

An analysis of ICT technology trends (basic ICT, energy, user interaction etc.) as well as an overview of recently emerging ICT services (e.g. intelligent charging, personal travel companion) for smart, clean and efficient urban mobility was carried out and related service bundles were identified. The impacts of ICT technology trends on the development and deployment of emerging services were shown and a technological assessment was done. The analysis shows the most important enabling technologies needed to realize the services (in large scale). Several champion technologies were identified which will play an important role in the future. Wireless networks, especially cellular networks and mobile communications, will be in a central role in the service provision to the mobile devices. Here broadband and flat rate pricing will also bring entertainment and infotainment as drivers to the mobile service scene. Mobile devices (smartphones, tablets etc.) provide the most convenient way to interact with many of the traffic related services, especially in multi-modal traffic context. Location technologies are central enablers to contextualize services and provide context to collected data. In mobile payment, Near Field Communications (NFC) will be a central technology, in addition to payment this technology opens many new opportunities also in other service areas. Sensors will be everywhere to observe the environment, provide data and control systems. The envisioned Internet of Things and Machine to Machine related technologies will also emerge to manage the increasing complexity of sensor networks. Since real-time requirements and spatial computing puts pressure on computer power, massive data management will be in the heart of many traffic services that are based on the holistic view on urban traffic. Cloud computing in its various forms provides solutions for computing- and data-intensive tasks. Innovative, contextual and safe user interaction is a paramount feature of services in the traffic context. Therefore, new solutions utilizing, e.g. multimodal and natural user interfaces will be developed. Privacy and security solutions will also be under tight inspection as many of the traffic related services can potentially reveal for example users' whereabouts and nature of activities. Integration of currently separated services to serve the whole (possibly multi-modal) mobility processes will be one of the key issues of future services. These technologies and aspects should be considered in future strategic research and innovation agendas.

A service impact assessment of all considered services was carried out in respect to their economic, social, political and technological impacts. These potential impacts can be within city limits, reaching regional, national, European or global level. These impacts were accompanied with a description of the impact describing their potential magnitude. The results show that impacts of various bundles, and even services, vary a lot. Most significant impacts, perhaps not surprisingly, are those that are linked with technological changes. It should be noted that different services require varying amounts of investments, which can affect the speed of providing the service to the market in real life. Social impacts appear to be the least significant; in particular to see cohesion improvements is difficult in most cases. The exception to this rule are social media applications, which can be considered to bring new users to traditional social media as a result of the benefits that they will gain from combining social media applications with their transport system information needs. The comparison of the various bundles from both a sustainability and an efficiency point of view shows that electric mobility services score the highest overall impact, with booking and payment having the lowest overall impact. In terms of the policy advice arising from the assessment, supporting urban logistics services could have the biggest impact on the system's efficiency.

As final part of the study, recommendations were developed for each of the services, showing the needs to (further) development/deployment as well as relevant stakeholders who need to be involved for supporting a fast take-up. Overall it can be concluded that from a technological point of view most technological requirements for a specific service are already available to a certain extend and a certain quality. Most of the proposed improvements lie in the organizational area, where standards for data and formats including the respective quality need to be established, therefore the involvement of all relevant stakeholders is necessary. The integration of services of different kinds and sectors needs to be achieved to create a greater gain in all sectors by integrating services into the

Smart City, which will also provide opportunities for a better integration of the individual in its urban environment.

1 Introduction

The European Commission has contracted a consortium to investigate ICT concepts for optimization of mobility in Smart Cities. The consortium consists of four partners: VTT (Finland), ISIS (Italy), POLIS (Belgium) and AustriaTech (Austria, coordinator).

The deployment of ICT mobility related services can help to address the challenge raised by urban transport under certain conditions. Indeed, ITS will play a prominent part in securing future sustainable mobility against a background of mounting economic, environmental and societal pressure. The provision of information can encourage more sustainable urban mobility behavior and at the same time a more efficient use of existing resources (energy, infrastructure, and vehicles). It can provide tools to better integrate all modes of transport, which means assigning a more important role to sustainable modes of transport. ICT can enable the full integration of the urban mobility system, which means integrating collective and private modes of transport, including public and private vehicles. It can therefore also enable advanced traffic management, increasingly addressing the movements of persons and goods and not only of vehicles.

There is a significant potential for improving urban freight delivery. This requires ICT services and interfaces, to establish better communication and exchange of information between all the stakeholders of this sector. However we also know that ICT alone cannot be an end in itself and would not be sufficient to improve the urban mobility system. The purpose of this study is to assess how and to what extent, considering future economic, social and technology trends, it can best contribute to the achievement of the European objectives.

The greater deployment of ICT services enables new solutions for mobility such as electro-mobility. The integration of services of different kinds and sectors is enabled by ICT and allows for the emergence of Smart Cities. Greater gain can be achieved in all sectors by this integration of services in a Smart City, which will also provide opportunities for the better integration of the individual in its urban environment. A Smart City uses data, information and communication technologies strategically to[2]:

- provide more efficient, new or enhanced services to citizens,
- monitor and track government's progress toward policy outcomes, including meeting climate change mitigation and adaptation goals,
- manage and optimize the existing infrastructure, and plan for new more effectively,
- reduce organizational silos and employ new levels of cross-sector collaboration,
- enable innovative business models for public and private sector service provision.

It is important to assess how and to what extent the emergence of cooperative and participative individuals in the Smart City will contribute to greater efficiency of the system, better quality of life and more social inclusion.

The study should address the following research questions:

[2] Source: ARUP and the Climate Group

- Efficiency and effectiveness – are the emerging ICT concepts cost-effective and the best way of achieving the measured impacts?
- Relevance – are the potential impacts relevant to policy goals?
- Sustainability – are the potential impacts of lasting value?

This study intends to investigate the potential of these new trends and the impact they may have on urban transport. The study shall clearly assess the impact of urban policy objectives on the need for research and innovation in ICT in the area of transport. Future potential ICT-based mobility services for goods in urban and inter-urban environments will be taken into account.

The main objective of the study is to perform an analysis on how ICT applications can contribute to the optimization of mobility within the recently emerging European Smart Cities. The study shall focus on:

- New developments, trends and policy changes in the urban environment that would require new ICT research and development to optimize/replace mobility;
- Assessing the impact of new urban policy objectives in order to facilitate the definition of future strategic research and innovation agendas and EU policies for mobility-related ICT;
- Identification of new ICT concepts, on EU or international level, that have the potential to offer more optimized urban mobility solutions, while still creating a safe, clean and smart transport system;
- Providing a scenario for potentially changed mobility patterns based on available travel surveys, demographic prognosis and statistics;
- Potential for new ICT-based mobility services for goods in both urban and inter-urban environments.
- Identifying existing gaps in knowledge and future research needs.

The study is intended to support the decision making process concerning required policy actions in the area of ICT research, development and innovation by providing an assessment of the most important systems and models able to resolve some of the challenges related to smart, efficient, safe and clean mobility. The outcome of the work will be a roadmap for deployment of single scenarios and key technology bundles.

The following chapters provide more details on the approach and the outcome of the study:

- Overview of mobility patterns (travel surveys, demographic prognosis and statistics),
- Review of state-of-the-art of advanced ICT based mobility services in urban areas,
- Identification of emerging ICT concepts for optimizing mobility in Smart Cities, scientific and technological impacts,
- Assessment of social and economic impact and benefits of new emerging technologies, and
- Recommendations.

Figure 1 shows an overview of the work flow.

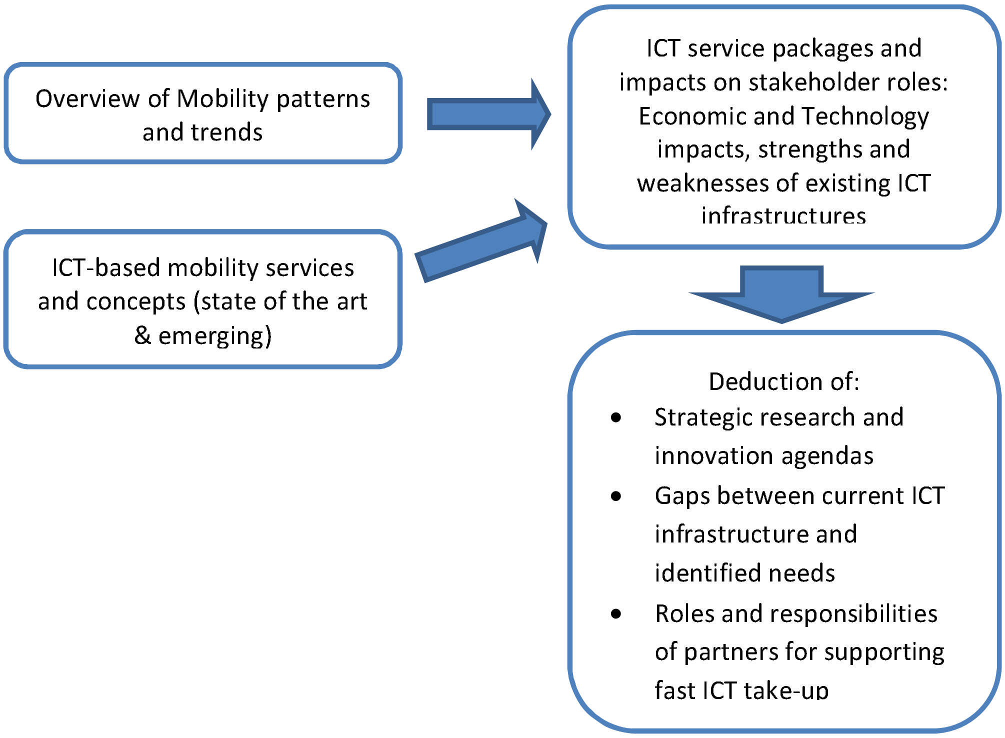


Figure 1: Overview of work flow

2 Overview of mobility patterns (travel surveys, demographic prognosis and statistics)

2.1 Introduction

This chapter outlines trends and policy changes in urban mobility patterns that would require new ICT research and development to optimize/replace mobility. In doing that, the historical mobility trends in the European urban areas have been analyzed through indicators and information provided by several databases (UITP, EUROSTAT Urban Audit, EPOMM, etc.) and national travel surveys (from Italy, France and UK).

The analysis has been conducted looking back at the recent historical patterns along an approximate time-span of the past twenty years (1989-2009) on the one hand and on the other, looking forwards towards the identification of the factors influencing the future mobility trends in urban areas.

This chapter comprises two main objectives:

1. Outline historical developments in mobility patterns, identifying future trends and transport policy challenges in the European urban environment;
2. Provide the knowledge base to identify new ICT mobility services to optimize/replace mobility and address the challenges.

Concerning the first objective, the analysis of the historical trends has depicted a situation in which:

- The urban sprawl leads to an increase of the average distance of trips, mainly carried out by car and in particular in the medium small cities (higher than 100,000 inhabitants).
- In the biggest agglomerations, a better availability of public transport and the higher costs of using cars cause a higher share of public transport than in smaller cities. This can raise the issue of the disconnection between car ownership rate and the use of a car, particularly in bigger cities where the daily usage of the car is lower than in other cities.
- In the biggest cities, the reduction of the average distance travelled associated to the increase of time spent in travelling, indicates the persistent phenomenon of congestion and the associated higher magnitude of social costs of transport (emissions, delays, noises, etc.).

The analysis of future trends affecting mobility in European urban areas has been carried out through an extensive literature review available on the matter (e.g. TRANSvisions study, 2009, PASHMINA EU research project, 2011), aiming at identifying future challenges and potential ITS services and applications. Three main challenges for the identification of which sound data and projections are available, have been emphasized:

1. Urban sprawl
2. Population ageing
3. Higher motorization rates

A fourth one, the future emergency of urban freight transport has also been mentioned, even if only scarce observations from some biggest city (e.g. Barcelona, Paris) are available.

Concerning the objective to provide the knowledge base to identify new ICT mobility services to optimize/replace mobility and address the challenges, a database for a sample of 44 European cities has been set up, which were selected based on the availability of a sub-set of indicators adequate to classify the cities according to the level of criticality of mobility patterns and vulnerability to future unsustainable paths. The selected indicators address both the structure of mobility (car ownership, population density, car density, public transport density) and the actual use of transport modes (modal share).

To develop the classification of the status of mobility, an indicator-defined index of impact severity was introduced to take into account the effects of the dimensions, travel distances and population density coming from the motorized component of the modal share. On the basis of a multi-component weighted combination of the database indicators and the index of impact severity the classification of cities in terms of level of criticality of the mobility status has been carried out. The result of the classification led to the consideration that the large cities (big and medium-big), consistent with the analysis of historical trends, are in critical position in terms of sustainability of mobility patterns.

The remedies to the critical conditions of mobility rely on development and implementation of Sustainable Urban Mobility Plans (SUMPs). The analysis of the SUMPs for a sample of seven large cities allowed selecting a list of transport policies for each of them, deemed to ensure a sustainable mobility in the future. The packages of policies and individual measures have been evaluated against their capability to address the "Key pillars of the sustainable urban mobility": more fluid, more accessible, safer, greener, and the smart pillar comprising the set of tools suitable to support the implementation, the monitoring and the enforcement of the mobility policies. The roles of ITS/ICT measures in each pillar have been identified and ITS applications were put in relationships to the main challenges on future mobility trends.

2.2 **Analysis of urban mobility data**

Five important indicators have been identified, on the basis of their relevance for urban mobility patterns and their availability in several European urban databases:

1. Population density (resident population per km^2), taken as a measure of physical (theoretical) pressure associated to the ratio between available space and potential mobility demand.
2. Car ownership (registered cars per 1.000 inhabitants); an important indicator of the stock of passenger cars in the city.
3. Car density (number of registered cars per km^2); indicates the pressure of the motorized private transport (cars) in relation to the available space.
4. Availability of public transport (total vehicle kilometers offered by the public transport in the city), as a measure of the supply-side offered capacity to match mobility demand by means of collective transport.
5. Modal shares (in percentage values) of private motorized transport, public transport and walking & cycling, as a concrete indicator of how current mobility patterns contribute to worsen/alleviate sustainability pressures.

The complete set of indicators is available for the following 44 European cities (core city, identified by the city administrative boundaries), which represent a balanced mix between big, medium-big, medium and medium small cities, with a broad European geographical coverage, as shown in Table 1:

City	Country	Population 2007-2009 (*)
Big cities: resident population > 1.000.000 inhabitants		
London	UK	7.668.300
Berlin	Germany	3.431.675
Madrid	Spain	3.213.271
Athens	Greece	3.074.160
Rome	Italy	2.718.768
Paris	France	2.181.374
Hamburg	Germany	1.772.100
Warsaw	Poland	1.709.781
Budapest	Hungary	1.702.297
Vienna	Austria	1.674.909
Barcelona	Spain	1.615.908
Munich	Germany	1.326.807
Milan	Italy	1.299.633
Prague	Czech Republic	1.233.211
Brussels	Belgium	1.048.491
Medium-big cities: resident population between 500.000 and 1.000.000 inhabitants		
Turin	Italy	908.263
Marseilles	France	852.396
Stockholm	Sweden	810.120
Valencia	Spain	807.200

City	Country	Population 2007-2009 (*)
Krakow	Poland	754.624
Amsterdam	The Netherlands	747.093
Seville	Spain	699.759
Stuttgart	Germany	600.068
Glasgow	UK	584.200
Rotterdam	The Netherlands	582.951
Nantes	France	579.131
Oslo	Norway	560.484
Helsinki	Finland	559.046
Copenhagen	Denmark	501.664
Medium cities: resident population between 300.000 and 500.000 inhabitants		
Lisbon	Portugal	489.562
Lyons	France	483.181
Manchester	UK	473.200
Dublin	Ireland	471.841
Tallinn	Estonia	401.389
Zurich	Switzerland	376.815
Bologna	Italy	372.256
Bilbao	Spain	353.340
Medium-small cities: resident population between 100.000 and 300.000 inhabitants		
Clermont Ferrand	France	279.621
Newcastle	UK	277.800
Graz	Austria	250.738
Ghent	Belgium	237.250
Lille	France	226.014
Geneva	Switzerland	185.726
Bern	Switzerland	128.345

Table 1: Population according to EUROSTAT (average 2007-2009)

Population density across Europe:

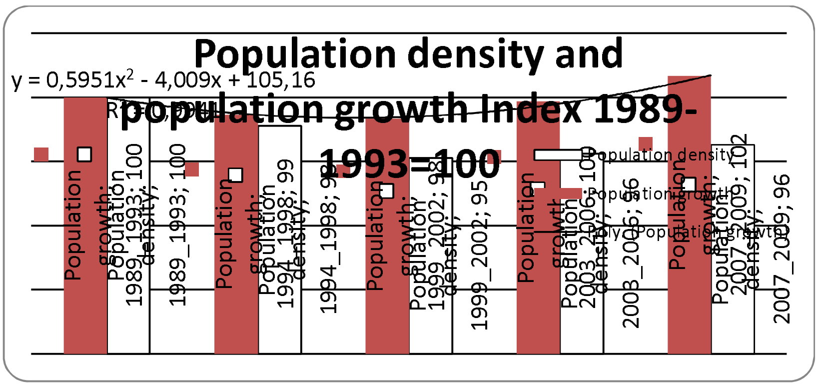


Figure 2: Population density and population growth trends

The population density in the sample cities is reported below:

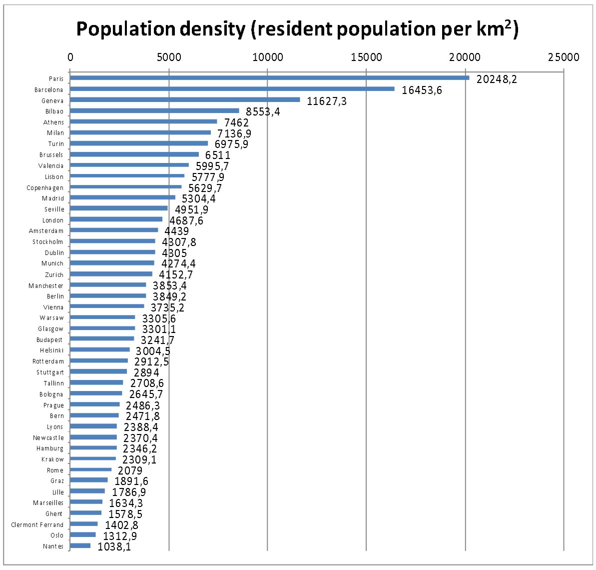


Figure 3: Population density (resident population per km^2)

The evidence of a growing population in presence of lower values of population density can be interpreted as a confirmation of the growing trends in urban sprawl, affecting the European urban areas over the past years [EEA, 2006].

Passenger cars per inhabitant

The number of cars per 1000 inhabitants in the sample of European cities shows in general a growing trend, from 377 (average 1994-1998) to 426 (average 2007-2009).

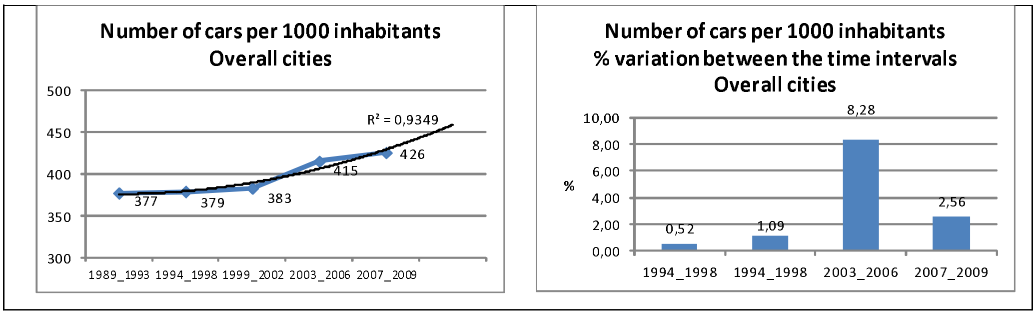


Figure 4: Number of cars per 1000 inhabitants in the sample of cities

However, in terms of percentage variation during the time intervals, a strong reduction in the 2007-2009 period (2,98 %) compared to the 2003-2006 period can be noticed, which registered an 8,28 % growth rate compared to the mid 90's level.
Over the past years, increased congestion levels and a better supply of public transport services in the biggest cities could have exerted a reduction of the willingness to own a car.

Car density

Car density (the number of registered cars per km^2) indicates the potential pressure of private motorization (passenger car) per km^2 of the city (administrative boundaries). The prevalence in big cities is evident.

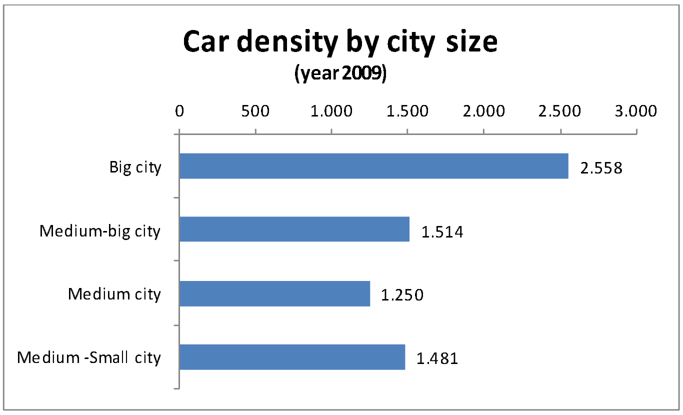


Figure 5: Car density by city size

Public transport density

The indicator of public transport density is the total public transport vehicle kilometers per urban hectare. This is equal to the ratio between total public transport vehicle x km and the urbanized surface area of the respective urban area.

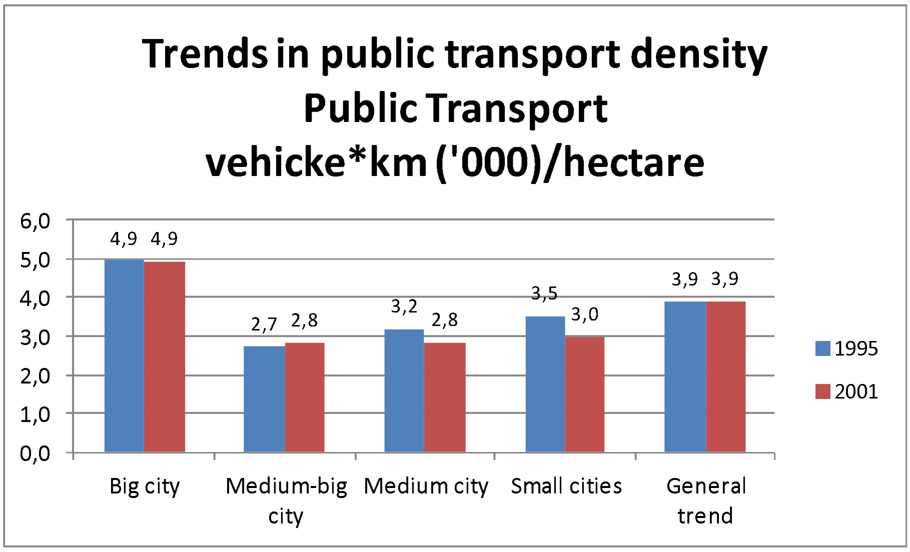


Figure 6: Trends in public transport density

The database does not allow the analysis of the trends in the first ten years of 2000. However, the trend towards a better availability of public transport in the biggest cities it is likely to be confirmed.

Modal share

The trends in modal shares have been analyzed in the light of their relationship to the different population density of the respective sample city.

1. City with high population density (> 5000 inhab./km^2)
2. City with medium population density (4999 ±2000 inhab./km^2)
3. City with low population density (< 2000 inhab./km^2)

Figure 7: Trends on modal shares and population density

Results show that the share of private motorized transport in urban areas increases inversely proportional to population density. The trend appears to be stable during the first 10 years of 2000.

Considering the public transport density, i.e.

- City with high public transport density (> 7000 vkm/hectare)
- City with medium public transport density (6999 ±3000 vkm/hectare)
- City with low public transport density (< 3000 vkm/hectare)

the modal share (motorized private vehicles, public transport and walking & transport) is reported below.

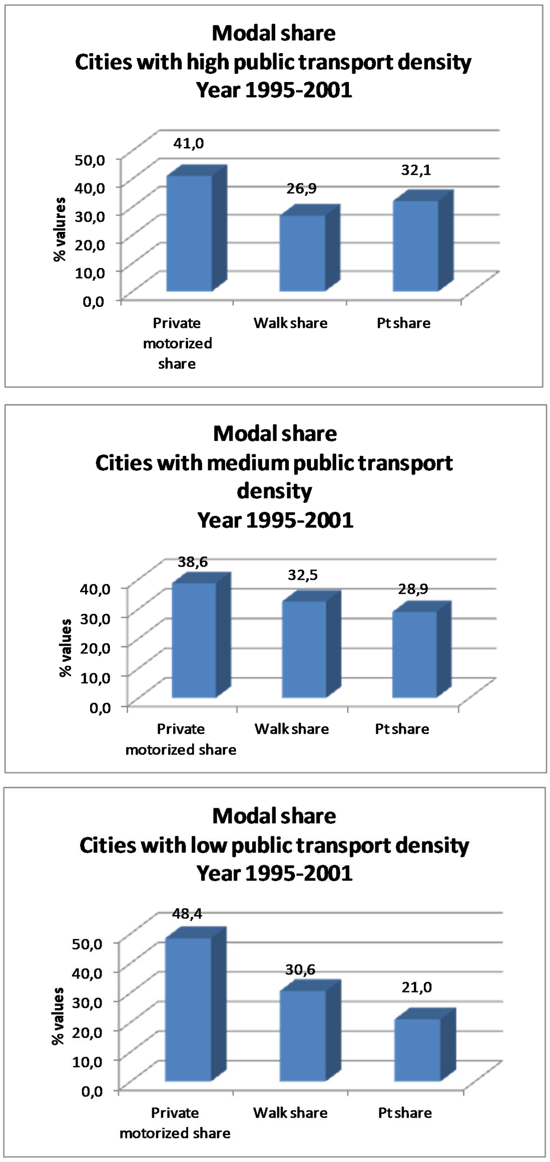


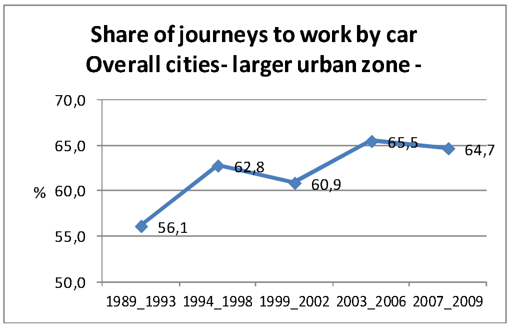
Figure 8: Modal share and public transport density

The figures confirm the propensity to the higher use of the car in cities with lower public transport density.

Larger urban areas

The analysis of mobility patterns involving both the city and the environment outside the urban administrative boundaries is important, since mobility flows related to the external environment generally represent a relevant share of the total flows, e.g. commuting flows.

Considering the overall cities, over the past twenty years a moderate upward trend in the use of car for home-to-work trips can be observed: from 56,1% (1989-1993) to 64,7% (2007-2009). In terms of variation between the time intervals, the use of private cars for commuting showed firstly a reduction by 3% in the early 90s, then an increase between 2003 and 2006 (+7,6%) and then a slight reduction between 2007 and 2009 (-1,2%).



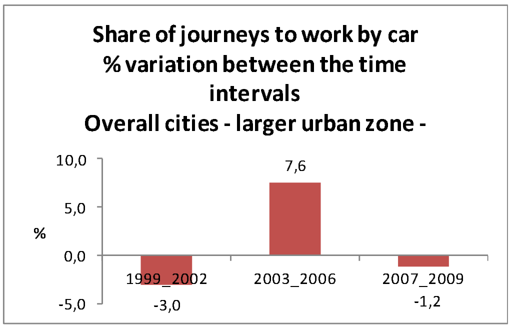


Figure 9: Larger Urban Areas: overall trends in using the car for trips

2.3 Categorization of urban areas in Europe

The sample of the 44 European cities considered in the analysis is characterized by a high coverage level relative to big cities, while, going down to smaller ones, the percentage gets smaller because of the very huge number of medium-small cities in Europe (see Table 2).

	EU27	Smart City sample	% of coverage
Big Cities > 1 million inhabitants	17	15	88%
Medium-big Cities 1 million inhabitants > EU27 cities > 500,000 inhabitants	40	14	35%
Medium Cities 500,000 inhabitants > EU27 cities > 300,000 inhabitants	60	8	13%
Medium-small Cities 300,000 inhabitants > EU27 cities > 100,000 inhabitants	337	7	2%
Tot		**44**	

Table 2: Smart Cities sample

On the basis of the five indicators considered, the assessment of sustainability of mobility patterns in the investigated sample of European cities has been carried out by implementing the following steps.

A) Categorization of indicators into three classes

As illustrated in the table below, for each indicator three classes of values – high, medium and low – were defined, whose thresholds are based on expertise with some degree of arbitraries.

CITIES	High	Medium	Low
Population Density *(Inhab./km²)*	> 5000	2000 ÷ 5000	< 2000
Private Motorization *(cars/1000 Inhab.)*	> 600	300 ÷ 600	< 300
Car Density *(cars/km²)*	>1000	300 ÷ 1000	< 300
PT Density *(vkm/hectare)*	> 6000	3000 ÷ 6000	< 3000
Modal Shares: *(%)*			
Non-Motorized	>30%	15% ÷ 30%	< 15%
Public Transport	> 30%	20% ÷ 30%	< 20%
Private Vehicles	> 45%	30% ÷ 45%	< 30%

Table 3: Categorization of the indicators into three classes

B) Identification of an 'impact severity index' for each of the sample cities.

This index refers to the risk analysis methodology. In the scientific literature, in fact, the concept of damage can be brought back to the expected risk towards a population or a territory subjected to the action of a danger factor. In this context, the index aims at assessing the state of mobility by taking into consideration the level of use of private vehicles for systematic trips. This parameter has then been assumed as representative of the solicitation, potentially damaging, induced by daily mobility choices of citizens. In quantitative terms, the 'impacts severity index' has been calculated by using the following formula:

$$\text{Impacts Severity Index} = D \times E \times V$$

where:

> D = dangerousness, as the potential harmful pressure made by the mobility system towards both the urban area and its inhabitants. This has been assessed through the extent of systematic trips made with private vehicles with relation to the urban area analyzed;
>
> E = risk exposure, as the population density representing the scale of magnitude of people at risk;
>
> V = vulnerability, considered constant and equal to 1, as the attitude of the territory to incur damages.

It has been considered appropriate to focus on the appraisal of externalities related to urban traffic flows, in particular the impact deriving from motorized private transport, namely the level of congestion (travel time, emissions, energy consumption, risks for vulnerable users, etc.). Results show that the focus has to be on the population density. In cities with both a high population density and quite a critical share of private motorized vehicles, in fact, the road network is generally more congested and consequently the externalities are greater. Because the value of the externalities is also linked to the length of motorized trips, the focus must also be on the dimension of the cities (of the homogenous urbanized areas).

Hence, not all the indicators have the same importance in favoring/hampering sustainable mobility impacts. That is the case if considering the modal shares of daily movements in the city, since, the incidence of private motorized transport means against the use of sustainable transport modes (public transport and walking & bicycle) has been considered as the most significant representing the main cause of negative impacts in terms of externalities, especially where the population density is high. On the other hand, car ownership rates or the density of public transport network could reflect the context drivers of the impacts.

The implementation of this approach results in the classification of European urban areas in four classes:

1. "High Critical Cities", where high density and extended areas and very high traffic intensity is combined with a high use of private cars and relatively low shares of collective transport and non-motorized modes. Such cities are considered "critical" in that they are most likely affected by acute air quality problems and high congestion levels.

2. “Medium Critical Cities”, for which although the intensity of traffic is high – thus entailing high congestion level –density and extension play a less relevant role and the modal shares are more favorable (Public Transport and/or walking and cycling play a significant role), thus mitigating the overall picture.
3. “Low Critical Cities”, where even an unfavorable modal split does not offset the major advantage of relatively low traffic intensity (“weighted” by the densities and the extensions).
4. “Non-Critical Cities”, for which the general condition does not generate relevant externalities and the “way to Tipperary” (sustainable urban mobility) is not very long

It is worth noting that in carrying out the categorization of cities the thresholds set for the ‘impact severity index’ (see Table 4) are based on both an educated guess and the values of indicators related **only** to the sample cities and therefore **cannot** be assumed as general thresholds assessing the critical mobility patterns for all the European cities. Moreover, grey areas could be found in proximity of the boundaries among contiguous groups, so that some cities could be classified “in between” two groups.

City Group	Impacts Severity Index Thresholds
High Critical Cities	> 5
Medium Critical Cities	1.5 ÷ 5
Low Critical Cities	0.5 ÷ 1.5
Non-Critical Cities	< 0.5

Table 4: Impact Severity Index Thresholds

The following bubble chart illustrates the four city groups in which the index value is represented by the bubble radius.

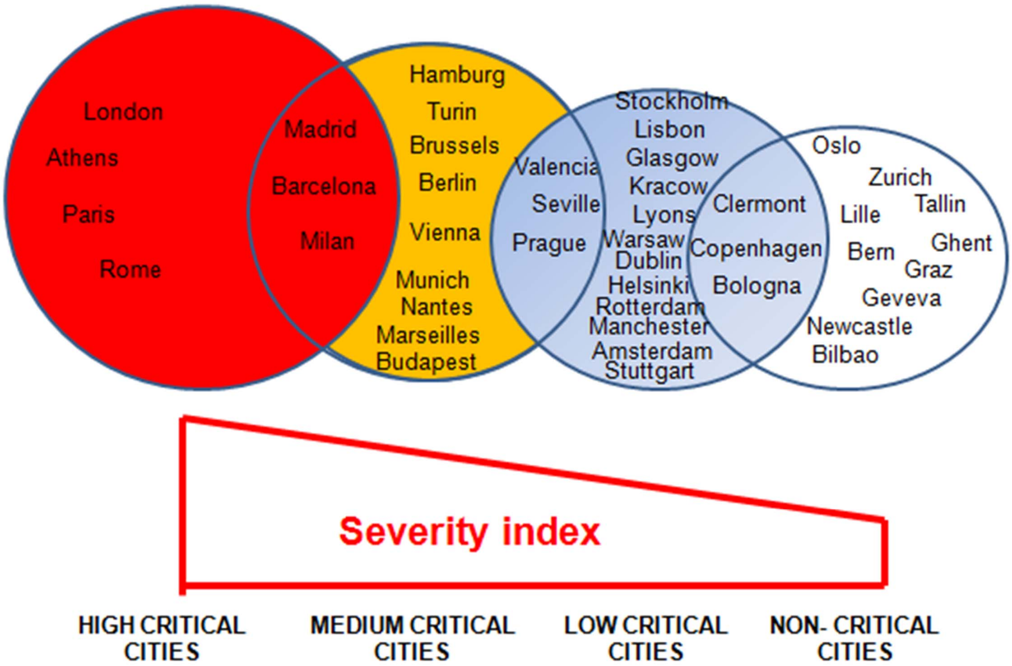


Figure 10: Identification of four city groups

All in all, **16%** of the 44 sample cities come within the highly critical area[3], **27%** within the medium-critical area[4], **34%** within the low critical area[5], while the remaining **23%** can be considered as non-critical[6].

---

[3] London, Athens, Paris, Rome, Madrid, Barcelona, Milan

[4] Hamburg, Turin, Brussels, Berlin, Vienna, Munich, Nantes, Marseilles, Budapest, Valencia, Seville, Prague

[5] Lyon, Glasgow, Amsterdam, Manchester, Lisbon, Dublin, Stuttgart, Stockholm, Krakow, Rotterdam, Helsinki. Warsaw, Copenhagen, Clermont Ferrand, Bologna

[6] Oslo, Lille, Zurich, Tallin, Ghent, Graz, Geneva, Newcastle, Bilbao, Bern

2.4 Future challenges and urban transport policies

The degree of risk that characterizes each city can be reflected in the challenges that the Green Paper has identified in a comprehensive way classifying them into so-called "five pillars of the sustainable urban mobility" (i.e. more Fluid, Greener, Safer, more Accessible and Smarter). Showing how to make the system "smarter" is the aim of this study, together with the actions required to achieve the necessary level of smartness.

The policy instrument to tackle these challenges and consequently with the aim of decreasing the city severity index has been identified in the Sustainable Urban Mobility Plan (SUMPs). A Sustainable Urban Mobility Plan aims to create a sustainable urban transport system, by addressing at least the following objectives:

- Ensure the transport system is accessible to all;
- Improve the safety and security of its users;
- Reduce air and noise pollution, greenhouse gas emissions and energy consumption;
- Improve the efficiency and cost-effectiveness of the transportation of persons and goods;
- Enhance the attractiveness and quality of the urban environment.

The policies and measures defined in a Sustainable Urban Mobility Plan should comprehensively address all modes and forms of transport in the entire urban agglomeration: Public and private, passenger and freight, motorized and non-motorized, moving and parking.

In the CONDUITS project (2011), a sample of European cities (Barcelona, Brussels, Edinburgh, London, Munich, Paris and Rome) provided information relative to their medium – long term transport plans. From the analysis of the long term plans of these cities, the main policies (excluded infrastructures) considered as a priority of each of them have been extracted and classified according to their influences in coping with the "challenges".
Besides the specific wording assumed by each city together with a certain number of local details, Table 5 shows a very high degree of similarities between the city policy goals and actions.

PILLARS	Barcelona SUMP Goals	Brussels SUMP Goals	Edinburgh SUMP Goals	London SUMP Goals	Munich SUMP Goals	Paris SUMP Goals	Rome SUMP Goals
MORE FLUID	High-quality, integrated PT.	Increase the PT daily frequency.	Online information system for PT.	Increasing PT capacity.	Optimize freight traffic.	Increase PT frequency, density of the service, priority roads, bus lanes.	Improve main interchanges nodes.
	Strong enforcement violations to traffic flow.	Dedicated lanes.	Management of private traffic.	Improve journey planning and information.	Cooperative city logistics.	Special PT services for commuter and schools.	Increase the offer of Park & Ride.
	Promotion of residential parking.	Car sharing scheme.	Guidance to parking structures.	Management of private traffic.	High-quality, integrated PT.	Increase freight delivery by non-car transport modes.	Monitoring management of the tram network.
	Parking structures supporting modal connections.	Collective traffic.	PT dedicated lanes.	Development of vehicle-infrastructure cooperative systems.	Demand management to inner city traffic.	Promote biking and bike-sharing.	Increase of PT to modify modal split.
	Promote car-pooling.	Company travel plans.	Improve main interchanges nodes.	Promote biking and bike-sharing.	Management of private traffic.		Demand management to inner city traffic.
	Promote biking and bike-sharing.	Parking structures supporting modal connections.	Promote biking and bike-sharing.		Promote the use of metropolitan and suburban railway systems.		Promote biking and bike-sharing.
		Promote biking and bike-sharing.			Promote biking and bike-sharing.		
		Optimize freight traffic.					
SAFER (more secure)	Enforcement of speed limits.	PT passenger's safety.	Increase the 20 mph zones.	Implementing road safety measures.	Implementing road safety measures in residential areas.	Low speed roads and safe crossing.	Improve of the fining system and procedures efficiency.
	Improve accident and emergency services.	Implementing road safety measures in residential areas.	Implementing road safety measures.	Reduce the numbers of road traffic casualties.		Implementing road safety measures.	Improve safety standards on board PT.
	Inclusion of new			Reduce casualties			Implementing road

PILLARS	Barcelona SUMP Goals	Brussels SUMP Goals	Edinburgh SUMP Goals	London SUMP Goals	Munich SUMP Goals	Paris SUMP Goals	Rome SUMP Goals
	safety measures for fleet acquisition.			on PT networks.			safety measures.
	Make it easier to cross streets/avenues on foot.			Improve the safety and security of stations in PT waiting areas.			
GREENER	Influence inbound city traffic.	Reduce noise and emissions.	Promote the share of sustainable modes.	Reduce air pollutant emissions.	Promote the share of sustainable modes.	Promote the share of sustainable modes.	Promote use of Park & Ride.
	Place a special emphasis on residential parking.	Extend the bicycle sharing scheme.		Reduce noise and emissions.	Support car-sharing and car-pooling projects.	Increase freight delivery by non-car transport modes.	Develop an eco-friendly PT fleet.
	Parking structures supporting modal connections.	Promote cycling at school.		Promote the share of sustainable modes.	Support taxi services.		Reduce noise and emissions.
	Promote car-pooling.	Integration of urban cycling network.			Increase Park&Ride and Bike&Ride facilities.		
		Car sharing scheme.					
		Support collective taxi services.					
		Company travel plans.					
MORE ACCESSIBLE	Achieve high quality, integrated PT.	Improve accessibility on PT for commuters.	Provide an integrated ticketing system within the city.	Improve accessibility on PT for commuters.	Develop PT plans to enable urban compatible mobility.	Promote the share of sustainable modes by dedicated structures.	Implement an automatic parking management.
	Parking structures supporting modal connections.	Integration of urban cycling network.	Increase Real Time Information signs at bus stops.	Improve access to commercial markets for freight movements and business travel.	Increment the relatively high current share of public metropolitan and suburban commuter railway systems.	Real time information systems.	Improve the call service for disabled people.
		Multimodal	Create a	Improve the	Real time	Multimodal	Improve the

PILLARS	Barcelona SUMP Goals	Brussels SUMP Goals	Edinburgh SUMP Goals	London SUMP Goals	Munich SUMP Goals	Paris SUMP Goals	Rome SUMP Goals
		ticketing system.	contemporary, multi-modal transport hub within city center.	physical accessibility of the transport system.	information systems.	ticketing system.	school service.
		Introduce preferential fares for youngster and disadvantaged groups.	Increase information in foreign languages.	Increase information on accessible and disabled buses.			
		Provide multi-media dynamic information services.	Increase information on accessible and disabled buses.	Improve journey planning and information.			
				Increase door-to-door services.			
				Improve lighting and public address systems.			

Table 5: Correspondence between Green Paper Pillars and CONDUITS cities SUMP Goals

Standing the commonalities of the mobility problems, the priority given by a certain city to a bundle of ITS applications is strictly related to the policies defined within medium term mobility plans.

Table 6 gives an overview of a sample of ITS/ICT solutions that a city may implement when addressing the sustainable mobility in terms of the main pillars directly connected to the aim of this study – and so for decreasing its impacts severity index – as emerging from the Sustainable Urban Mobility Plans of the CONDUITS sample of European cities.

PILLARS	**ITS APPLICATIONS**
More Fluid	Urban Traffic Control
	PT Priority
	Fleet Tracking
	Service Regularity
	Loading Bay Monitoring
	Parking Guidance
	Parking Availability
	Traffic Guidance
Safer	PT Video-surveillance
	Speed Alert
	Pedestrian Management
	Incident Management
More Accessible	PT Passengers Information on-ground
	Pre-trip Information by Fixed devices
	PT Passengers Information on-board
	Pre-trip Information by mobile devices
	On-trip Information by VMS
	On-trip Information by portable devices
	On-trip Personalized Information
	Parking Booking
	PT Ticketing
	Parking Payments
	Alternative Services Payments
	Services for disadvantaged people

Table 6: Correspondence between pillars and ITS applications

For the seven EU cities investigated in CONDUITS, the applications already in place, and the ones foreseen to be implemented to mitigate the actual level of risk have been identified (see Table 7). It can be observed that urban traffic control applications and on trip information devices are most frequently included amongst the ITS measures to tackle future criticalities.

Of course, it would be necessary to know the results of the SUMP implementation and, consequently, their effectiveness to reduce the level of risk of the city, for assessing the usefulness of a certain bundle of ITS applications.

ITS applications already in place ●

ITS applications foreseen in the near future ■

		Barcelona	Brussels	Edinburgh	London	Munich	Paris	Rome
MORE FLUID	Urban Traffic Control	● ■	●	●	●	● ■	● ■	● ■
	PT Priority	●	●	●	●	● ■	● ■	●
	Fleet Tracking	●	●		●	●	●	●
	Service Regularity							
	Loading Bay Monitoring	●						
	Taxi Monitoring		●			●	■	
	Parking Guidance		● ■	●		●	● ■	
	Parking Availability	■	●	●		●	■	
	Traffic Guidance	●	●	●	●	●		●
SAFER	PT Video-surveillance							
	Speed Alert	●	●		●			●
	Pedestrian Management	●	■					
	Incident Management	■	■	●				
MORE ACCESSIBLE	PT Passengers Information on-ground	●	●	●	●	● ■	●	●
	Pre-trip Information by Fixed devices	●						
	PT Passengers Information on-board	●	●		●	● ■	●	●
	Pre-trip Information by mobile devices	■	●	●	●	● ■	● ■	●
	On-trip Information by VMS	●	●	●		● ■	●	●
	On-trip Information by portable devices	●	●			■	■	● ■

ITS applications already in place ● ITS applications foreseen in the near future ■		Barcelona	Brussels	Edinburgh	London	Munich	Paris	Rome
	On-trip Personalized Information					■		■
	Parking Booking	■	●				■	
	PT Ticketing	■	●	●	●	●	● ■	●
	Parking Payments		●	●				●
	Alternative Services Payments							
	Services for disadvantaged people			●	●	●		

Table 7: ITS applications in CONDUITS cities

2.5 The future trends: urban sprawl, motorization rates and population ageing

In Europe the proportion of the population residing in urban areas is expected to rise from 72 % in 2005 to 78 % in 2030 with an increase of 0.3 percentage points every year.

Urban sprawl

Urban growth is accompanied by urban sprawl – a relative shift in the location of activities (housing, industries, retail and other services) towards the peripheries of the urban agglomeration. This was and currently is an established trend that affects the growth of modern cities, which is time after time associated with a gradual decrease in density at the center, and a decrease in the rate of density reduction depending on distance from the center.

Motorization rates

The above trend determines a growing use of car and private motorization modes. A faster increasing chance for jobs in the suburbs and on the urban fringes rather than in the centers and inner districts of metropolitan areas is characteristic for all developed countries. The location of high-tech and often footloose enterprises is relatively independent of the location of raw materials and markets. Fast accessibility to regional, national and international markets is gaining importance at the expense of proximity. All these developments (urban sprawl) will lead to the growth in the use of private motorizations rates in metropolitan areas.
Furthermore, the movement of warehouses and logistic terminals from the urban areas to suburban zones well known as "logistic sprawl", results in increased mileage travelled by trucks and vans as final trips to the city core.

Population ageing

Elderly people are travelling more than before, making more trips by car and walking less. Furthermore, the size of the elderly population is rising. As well as the environmental impacts of these changes, it is important to consider the specific mobility needs of this population and to ensure that they continue to have access to local shops and services. This will enable elderly people to continue living at home and encourage walking – particularly important from a health perspective. This trend is deemed to raise in the future the more general issue of travel for people with reduced mobility.

2.6 The potential role of ITS services

As identified in the previous chapter, apt to effectively address the main issues on future mobility trends are:

- Urban sprawl
- Population ageing
- Higher motorization rates

The SUMPs the cities are envisaging to develop should consider at the forefront of priorities those issues. It is expected that the smart component of the plans will identify the ITS applications that each city consider the most effective in supporting its policy goals, similarly to the evidences previously reported for the seven cities sample.

Table 8 aims at illustrating the relation that can be established between ITS tools and the future mobility trends to be possibly considered in the SUMPs. A single tick (√) in the table marks the importance of the respective ITS application to address the urban agglomerations topics, while a double tick (√√) indicates the particular (most relevant) capability of the ITS application in doing that.

PILLARS	ITS APPLICATIONS	CHALLENGES OF FUTURE MOBILITY TRENDS		
		Urban Sprawl	Population ageing	Higher motorization rates
MORE FLUID	Urban Traffic Control			√
	PT Priority	√		√
	Fleet Tracking	√		√
	Service Regularity	√	√	√
	Loading Bay Monitoring			√
	Taxi Monitoring		√√	√
	Parking Guidance	√		√√
	Parking Availability	√		√√
	Traffic Guidance		√	√√
SAFER	PT Video-surveillance		√√	
	Speed Alert		√√	
	Pedestrian Management		√√	√
	Incident Management		√	√√
GREENER	Access Restrictions	√		√√
	Park-and-Ride	√√		√
	Bike-and-Ride			√
	Car Sharing		√	√√
	Bike Sharing			√
	Car Pooling	√√	√	√
	Freight Delivery Access/Time Slot Monitoring	√		
	Other Traffic Management Systems	√		√√
MORE ACCESSIBLE	PT Passengers Information on-ground		√√	√
	Pre-trip Information by Fixed devices	√		√√
	PT Passengers Information on-board		√	√
	Pre-trip Information by mobile devices	√√		√
	On-trip Information by VMS		√	√
	On-trip Information by portable devices			√
	On-trip Personalized Information	√	√√	√
	Parking Booking	√		√
	PT Ticketing	√	√	√
	Parking Payments	√		√
	Alternative Services Payments	√	√	√
	Services for disadvantaged people	√	√√	

Table 8: ITS applications and the future challenges of urban mobility

3 Review of state-of-the-art of advanced ICT based mobility services in urban areas

3.1 Introduction

This chapter establishes an overview of the current level of deployment and use across Europe of ICT based services relevant for mobility in urban areas. In its main part it addresses the deployment of services, and ends by discussing the regulatory and policy framework and the identified and perceived barriers and expectations of local authorities regarding the deployment of ICT for mobility.

The overview of services is done with an analysis of the literature as well as a survey of a group of cities which have been addressed by a questionnaire. The 44 cities proposed in Table 1 are the main targets for this questionnaire which is also sent to a larger group of cities. The questionnaire (see ANNEX B – Questionnaire on the deployment of ICT mobility related services in cities across Europe), is established using the classification of services proposed in the previous chapter. The overview is further presented in this chapter considering broader categories of services. Examples for some of the described ITS services can be found in ANNEX A - Examples of ITS services in cities.

3.2 Overview of the deployment of ITS application in cities across Europe

The survey conducted in this study revealed some important obstacles regarding the establishment of a comprehensive overview of ITS applications across cities in Europe. The diversity of services and of entities responsible for their implementation and management makes it difficult to obtain a comprehensive overview which does not exist as such in many cities. Responsibilities for ITS services are scattered among various local actors such as the traffic management department of the city, the transport authority and the public transport operators. In addition, a significant number of mobility services in the city are provided by private operators. They can be supported by ICT services that they develop and manage, for instance for car sharing or bike sharing but which can also be developed by third private parties. As a result, it was not rare to identify during this study some services identified by the authors in their analysis which were not known by most of the officials of the city.

The subjective view of the respondents and the diversity of policy objectives, which shade lights on their assessment of ITS, have also influenced the answers which should be taken cautiously. We present in this section a rapid overview of the results of the survey, which are also integrated in the following section.

It should be noted that cities from all size groups identified in Table 1 answered to this survey. Also cities from all levels of criticity (Table 4 and Figure 10) answered to the survey. However, answers were provided by a much larger proportion of large and medium size cities, which explain in some cases the high proportion of deployment of ITS services. It is likely that if more cities of a smaller size had answered the survey, the level of deployment of some services would have been lower. Typically for instance, the smaller the city, less likely it is to have a traffic control center.

The survey reveals that the most common ITS applications are related to management of the signalized network. There is a strong emphasis on public transport priority. Passengers' safety at stations and on vehicles, as well as the ease of using the public transport system is also a main concern to the large majority of the cities. Social inclusion of the visually impaired traveler was also reported to be in the interest of the cities, as 75% of the cities that stated on disadvantage people ITS applications, were related to public transport. Even though coordination of the different networks in the urban environment is handled by incident management in most cities, ITS applications related to the Bike & Ride combination of modes, was found to be rather limited.

Pre-trip and on-trip traffic information, seldom based on taxi monitoring, as well as pre-trip and on-trip public transport Information, based on fleet tracking, is widely disseminated in various forms and by using mobile and static devices. Nevertheless, the possibility of providing personalized travelling information as well as the utilization of social media by smartphones is still quite rare.

Car-pooling which is also a social transport application, seldom includes ITS according to the persons surveyed. However, as several car-pooling services are run by private entities, it is possible that the answers underestimate the use of ICT to manage this service.

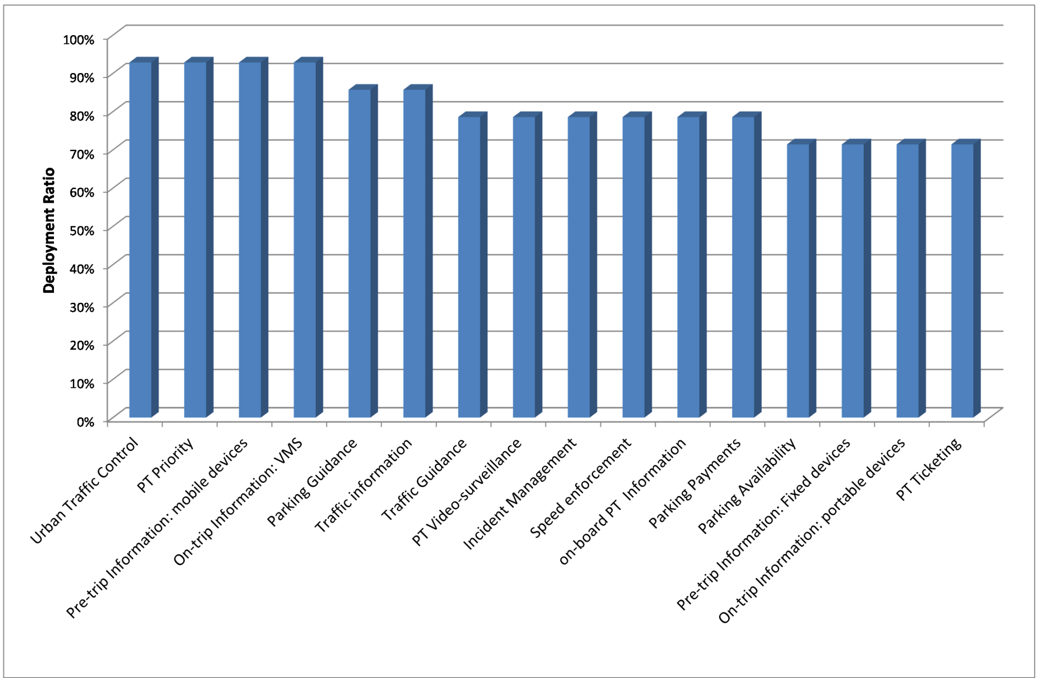


Figure 11: Overview of the deployment of ITS application (1)

Consumption of urban services by cars requires searching for a parking spot/lot and thus increases the distance travelled in the cities. To reduce that nuisance most of the cities provide traffic and parking related information, either as parking guidance or parking availability. Nevertheless, although parking booking can also support reducing the distance travelled in the search for a parking spot, parking booking remains very rare.

Half of the cities declare to promote multimodality by adopting ITS to its Park & Ride facilities. Parking payments can often be made electronically via smartcards, text messages or smartphone applications. Although 82% of the cities enable advanced parking payments, only a few enforce parking using ITS. Speed enforcement and red light violation are also common but in most cases it is not in the direct responsibility of the city transport authority. Access restrictions are common in cities, yet prevention of access and enforcement is mostly based on non-technological solution, especially for LEZ and heavy duty vehicles.

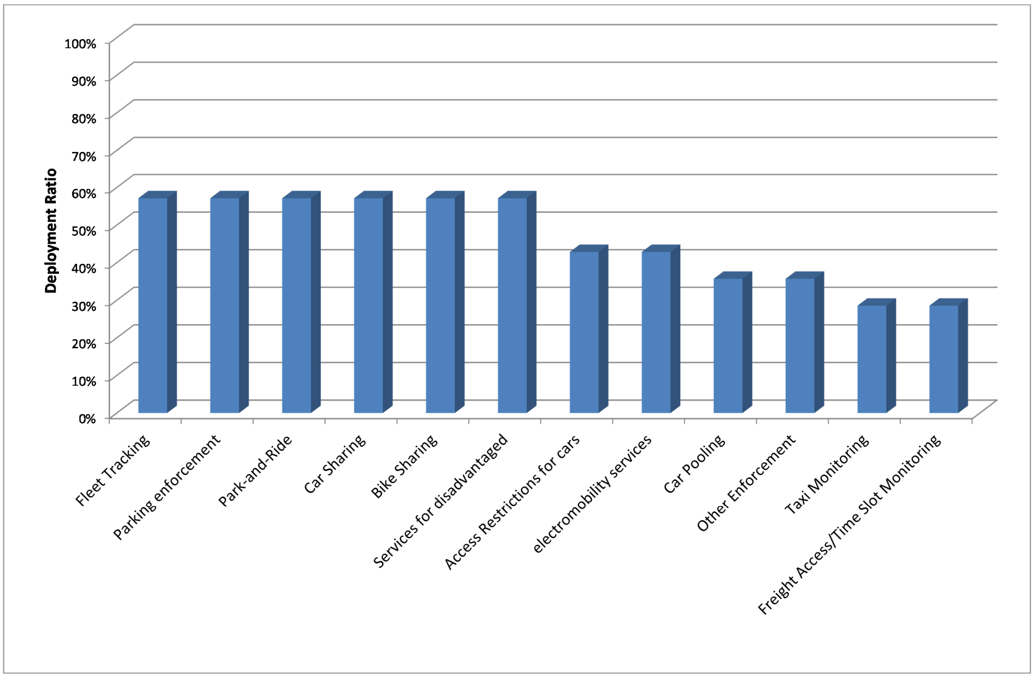


Figure 12: Overview of the deployment of ITS application (2)

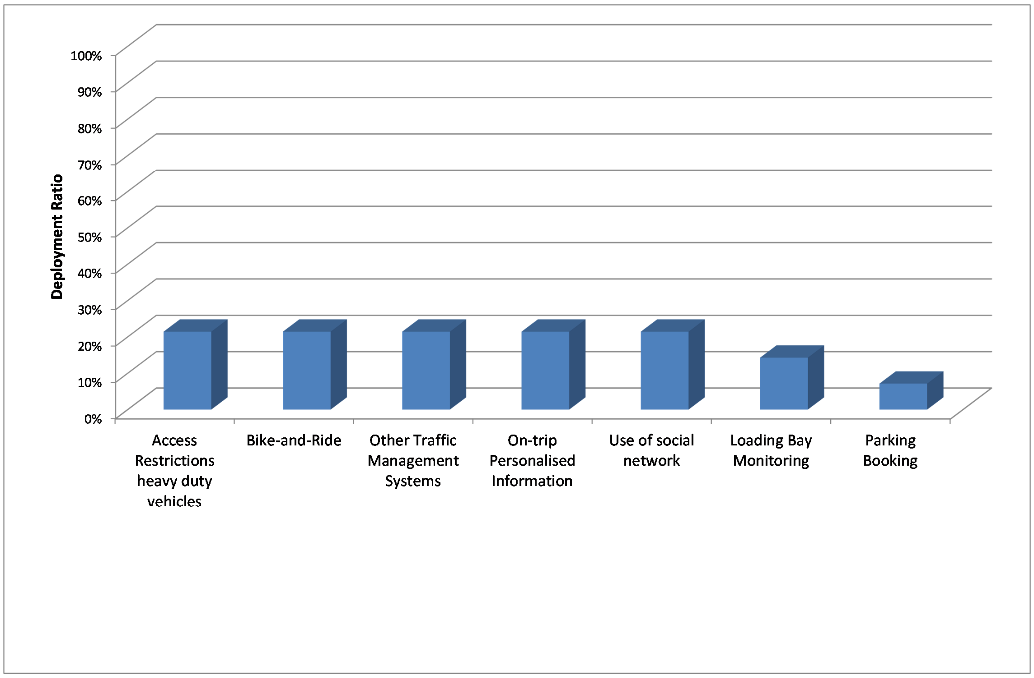


Figure 13: Overview of the deployment of ITS application (3)

3.3 ICT mobility based services across cities in Europe

3.3.1 *Urban logistics services*

Many cities across Europe are now developing full strategies to address urban freight delivery, integrating them in their urban mobility policies. These strategies rely on a broad range of tools, from access restrictions to urban freight consolidation. While several of these tools rely on ICT services, the main challenges associated to their efficient implementation are more related to the difficult business models and the challenges to engage all stakeholders.

Route Guidance service recommends a route for the vehicle navigation system to support freight vehicles around congested/environmental zones and to distribute the traffic load on alternative routes. It aims at creating a better traffic flow. Some special use cases include for instance the guidance of freight vehicles around environmental zones and to avoid low tunnels and bridges with information on special routes for certain types of freight vehicles (heavy, electric).

The management of parking, loading and unloading areas includes systems enabling the use of some areas informing of its availability. This is for instance the case for the VMS deployed in Barcelona since the first CIVITAS programme for the multiuse of some road lanes. The management of loading and unloading areas also increasingly addresses the challenge of making it possible for freight vehicles to book a parking space for loading and unloading, as this is the case in Bilbao.

Access control provides freight vehicles access to restricted areas, for example environmental zones in cities where only a specific EURO class are allowed, or giving respectively denying vehicles carrying dangerous cargo access to tunnels with specific restrictions. In some countries, such as Germany, the implementation of access restrictions does not rely on ICT. In London, which allows electronic payment, enforcement checks the license plates recognized through cameras against a database of registered vehicles.

Smart Packaging is still fairly rare. It consists of equipping packaging with additional functions to create additional benefit for the user by using new materials and technologies (e.g. RFID). This service could also include the extension of eFreight to urban delivery to track parcels.

Cleaner and more efficient vehicles operations, can consist in incentives, network management and services related to ecodriving. An example is the prioritization of vehicles which are subscribed to ecodriving schemes, for instance in the framework of freight partnerships. The control of the refrigerating unit of freight vehicles which can be switched off depending on the level of noise generated by a vehicle at a certain point in time and space is being used for night delivery in Barcelona.

The consolidation of urban freight delivery can take place in various ways. To address the challenge of increasing the load factors of the vehicles entering the city and thus optimizing the efficiency of the urban logistics system, consolidation centers enable the consolidation of goods prior to the last mile and their delivery in the city. Through information on goods and destination, ICT is an important component of the consolidation centers. Bristol is one of the most efficient consolidation centers, which has been supported by the CIVITAS programme.

Consolidation can also take place at the delivery point, if this one is a collective one. There are now over 2500 DHL packstations distributed in most of the main German cities. The packstations are located in interchanges such as stations. DHL parcels are delivered in packstations. As soon as the parcel arrives at the packstation, the customer is notified by SMS and/or email. Customer can log in with their Goldcard (magnetic stripes) and PIN to retrieve the parcel. A similar system exists in other countries, for instance in Paris with la Poste, but also in Denmark, Poland, etc.

3.3.2 *Virtual mobility services*

Virtual mobility refers to a set of technologies that provides alternatives for activities which requires mobility solutions. It includes telecommuting, teleshopping and teleleisure. In most cities, a large share of the annual trips are work-related, thus telecommuting is associated with travel decrease for example by telepresence, especially teleworking, which is growing rapidly in some countries.

Collective work places, or coworking centers offer places for workers where they can find fully equipped working space and offices. These are located nearer to their homes and to transport interchanges than their company offices. They also encourage cross-fertilization between activities and companies. Coworking centers are now fully functioning in a large number of cities across Europe. Several of them are operational in Paris for instance.

Figure 14: La cantine in Paris offers coworking space

In the Netherlands, smartwork is developing coworking in many places, starting in Amsterdam. Cisco, ABN AMRO, Rabobank and Touchdown Center are the founding parties. A smart work center is defined as a physical facility where high quality workplace solutions are offered to professional workers in a neutral, centrally located and easily accessible environment. To minimize traffic, a Smart Work Center is located in the vicinity of roads, traffic junctions, stations and residential areas.

3.3.3 *eCommerce*

The growth of eCommerce raises several questions of high importance for the deployment of sustainable mobility solutions in Smart Cities. eCommerce significantly influences the number of trips made in the city for shopping or freight and parcel delivery. Depending on how it is supported by other ITS tools for urban freight delivery for instance, it can reduce the need to travel and as thus be a full component of the Smart City.

Regarding the impact of ICT on travel, some authors showed that [Andreev et.al., 2010] substitution was found to have the most prevalent impact on telecommuting, while complementarity has a major impact on teleshopping and teleleisure. These findings have to be regarded in light of two other findings. The majority of studies investigated ICT impacts in the short term while in the long term ICT impacts are still unclear. Furthermore, the review revealed that the cumulative impacts, such as how telecommuting affects teleleisure or vice versa, remain unstudied.

3.3.4 *Urban Network Management Services*

Urban Network Management (UNM) is a core activity in vital cities. UNM is a set of methods and technologies to effectively allocate the transport infrastructure. Traffic management & control strategies are implemented with traffic management systems (TMS) and aim at supporting policy objectives such as safer and more sustainable transport systems, higher competitiveness of the territory and higher quality of life.

3.3.5 *Speed Management*

Speed Management (SM) procedures yield dynamic information to the road user about recommended or prevailing speed. SM is mostly used in the urban network to warn drivers about their speed compared to the recommended speed, which is set on the base of either safety or operational goals.

3.3.5.1 *Intelligent speed adaptation*

Whereas the cooperative traffic systems concentrate on the system as a whole, striving to improve the flow of all users together, Intelligent Speed Adaptation (ISA) systems, put a greater emphasis on the individual vehicle. This is done with regard to the driving speed. A GPS device informs or forces the allowed speed on the vehicles, thus contributes to safety and to reduce emissions. Until now, ISA has been trialed and implemented in different cities and regions in Sweden and the UK for instance.

3.3.5.2 *Speed enforcement cameras*

Speeding is the most important cause of traffic death and injury across Europe. Speed Enforcement Cameras (SEC) are deployed in larger scale at the inter-urban network although can also be found in nearly every large and medium European city. SEC is widely diverse in the technology implemented, from wet-films to digital cameras enabling nearly fully automated ticketing.

3.3.6 *Traffic Control*

Traffic control was the first domain for which ITS was developed. One of the most powerful measure urban road authorities can take for policy implementation is the signalized junction network. By managing these, cities can promote selected modes, regions and activities.

Traffic control in cities is carried out in many ways, employs many systems and takes many different approaches. Traffic Control Systems (TCS) vary from fixed time systems to traffic responsive and from distributed processing to centralized systems. The type of systems deployed not only varies between cities but sometimes within the city itself. For instance, in Brussels 3% of the signalized network is operated by UTOPIA. In London 900 of the junctions are fixed-time programs with control updates, some 2.800 are vehicle-response isolated junctions and approximately 2.300 use a dynamic response Urban Traffic Control (UTC) by SCOOT. SCOOT is recognized as the first traffic adaptive system and its models are mostly based on the progression of private traffic. Later enhancements have allowed implementation of PT priority in SCOOT. In BALANCE and SPOT/UTOPIA, PT priority is an integral part of the models. SPOT/UTOPIA is implemented mostly in Italian cities such as Rome and Turin but also in some Scandinavian cities. Some of the Scandinavian cities still use PRIBUSS as a control strategy for PT priority. Other cities in Europe such as Zurich, Toulouse, York, Genoa, and others, implement policy priority in general and PT priority in particular using their own systems.

The CALIRE/ClaireSiti system is a multimodal platform for urban area transport networks developed by INRETS-GRETIA aiming to deal with congestion management and PT. Field tests have been managed via the ClaireSiti system (Paris, Toulouse and Orleans) in France. There is an operational site in Brussels which is used by STIB, Brussels PT operator.

Some cities, Dresden and Zurich for instance, built their own TCS. In Dresden the system is composed of several components such as parking information provision and guidance, multimodal routing recommendations and also a traffic monitoring system which serves as the basis for automated control actions. Zurich has implemented a fully centralized traffic signal operating system which controls 7 areas within the city, each in a duplex system and with about 60 traffic signals. The operating system involves some 14 process computers, and two central coordination computers, and over 3000 detectors in the road surface permit fully dynamic signal program switching. Full tram and bus priority is implemented at traffic signals throughout the city. In addition, 'access control' is implemented using traffic signals to meter traffic into any area of the city which would otherwise become overcrowded.

Either for central traffic management decision making or for the operation of the regulation in junctions, detection is required. In most cases vehicle detection is mainly performed using passive devices such as loop detectors, while pedestrian detection is mostly done by using push buttons. The PUFFIN (Pedestrian User-Friendly Intelligent) crossing tested in Southampton (deployed in other UK cities as well) requires both a push button and a kerbside detector (either a surface laid pressure mat detector or an 'above-ground' detector mounted on a traffic signal pole) to report the pedestrian demand to the signal controller. The green light for pedestrians is extended by means of on-crossing detection. The current PUFFIN detection method is incapable of identifying the number of pedestrians waiting to be served.

With the aim to improve the quality of life, 25 out of 32 European cities reviewed in the EC co-funded CONDUITS, implement PT priority for both major modes in their signalized network. The identification of PT vehicles approaching a junction is conducted utilizing different technologies. The most popular forms of bus identification are radio-beacons and loops. Regarding bus priorities, GPS-based location detection is the most accepted technology in European cities. Acknowledging the advantages of satellite based location identification, TFL recently deployed the iBus system which is based on GPS positioning

measurements supplemented by map-matching algorithms to precisely identify the bus location along the route.
Enforcing traffic lights regulation is essential for a well-functioning traffic control policy supporting an efficient urban transport network. This requires identifying red light violation identification of vehicles entering signalized junctions during the red period. In most cities, the violation is identified using image processing through Red Light Cameras (RLC).
Traffic control can enable public transport priorities. By aiming to increase the modal share of collective transport many bus reserved lanes were developed in cities around Europe. In Oxford city center, bus lane enforcement cameras are installed in 3 zones, in Sheffield similar approach was taken for 6 zones.

3.3.7 *Incident management*

While incidents on inter-urban highways are in most cases directly related to traffic, the causes and effects of incidents in the urban agglomeration are much more complex. As it stems mostly from local requirements and practical constrains, Urban Incidents Management (UIM) is considered a local 'art', and there are great differences between cities. Gdynia (PL) is developing a technology to identify collisions in junctions and change the signal timing plan accordingly. Another small scale incident management is evident in Ghent (BE) which alarms around public transport stations based on a potential of pedestrian spillback to the road.

Besides information dissemination of incidents in the majority of European cities, cities such as Athens and Brussels collect traffic data and notify the police about traffic incidents occurrences; Zurich use systems facilitating fire brigade vehicles through a green wave function that coordinates traffic lights to allow emergency vehicles to pass through series of intersections; and in Stuttgart and Karlsruhe the police and the fire brigade are members of an integrated traffic information system based on GIS-technology, that provides them with real-time information about road works and the level of service for the primary roads. Incident management includes three main building blocks: incident identification, operation of field devices (such as barriers closure, change of signal timing program), and dissemination of information. For the last years ICT has revolutionized the first and the last blocks. ICT applications, either transportation dedicated such as Waze© and TranzMate, or general social networks such as Twitter and Facebook, are vital tools for both incident identification and dissemination. The City of Haifa uses the driver's reports in Waze© as a source to identify irregular congestions. TFL closes the incident management loop by informing Londoners of transportation related incidents on Twitter. Public transport events in Berlin are also reported in Twitter by BVG Straßenbahn.

3.3.8 *Access control & Demand Management*

To contain congestion and the environmental impact of urban traffic, CC and LTZ are gradually expanding to more and more cities in various ways. In Rome, for instance, a LTZ was first introduced in 2001 for limiting access to the historic city center. In order to implement these restriction, 22 gates on access roads leading to the historic city center were constructed, each equipped with an optic detector for reading license plates using ANPR technology, triggered by inductive loop detection. London CC is based solely on ANPR identification of camera images. Stockholm CC uses a mixture of ANPR and wireless RFID technologies.

Some initiatives in cities, aimed at managing the demand through lane allocation, either static (PT reserved lames) or dynamic. Lanes are dedicated to public transport, to vehicles paying a (dynamic) fee, or to high occupancy vehicles. There are no deployed systems for the automatic enforcement of high occupancy lanes at the moment, only trials.

While traffic management and control mostly related to the tactic level, demand management is related mostly to the strategic level. For tactical demand management level two main tools are considered: VMS and signal programs. VMS traffic-related messages are well accepted but not always followed. They are less effective than signal programs.

3.3.9 *Electro Mobility*

While cities and regions across Europe adopt and implement programmes to support the deployment of electromobility, there is an increasing number of smartphone/web applications that provide electric vehicle drivers with their powering options. These applications are either 3rd-party applications, based on public databases or vendor's specific application.

The smart phone application LEMnet, electric vehicle Charging Europe provides information concerning the location of electric vehicle charging points with additional, though limited, route planning services. The database comprises several types of chargers suited for vehicles, scooters and bikes. Plug surfing is another smart phone application which allows European users to update the list of stations, add comments and even suggest their own home socket. e-kWh by RWE is a vendor-specific smart phone application which enables the user to view the current charging status, stop the charging, and other features. Payment with this application is also possible for costumers without a long-term contract. Better Place, which currently operates in Denmark, Israel and other countries, has a different business model. According to this model, the e-driver pays a monthly subscription fee depending on his average travel distance. In return, the user can avail him to the Better Place electric sockets around the city and at home as much as needed. The user can view his energy consumption data on the support center account and via the Oscar, electric vehicle management smart phone application. It is not possible to book a charging point with this application.

MOBI.E is a privately owned platform that currently runs a pilot which is expected to yield 1.300 normal charging points in 25 municipalities in Portugal. MOBI.E claims to provide not just charging devices from a variety of vendors, but also a unified payment system which can be expended to other transport-related payments such as tolling, public transport and more.

A smartphone application is available for AutoLib' electric vehicle car sharing scheme in Paris, enabling travelers to register to the AutoLib car-sharing service, plan their routes and check the availability of parking places, cars and charging stations.
There are already projects integrating ICT to optimize the charging schedule of the vehicles taking into account the energy demand. In Zurich, IBM and EKZ (a local electricity utility provider) make use of smartphone based applications to schedule the charging process of

the electric vehicle, using renewable sources (solar or wind) in addition to the conventional ones.

3.3.10 ***Access to Data/Information***

Transportation-related urban data can be assessed using two main sources:

1. City-owned measurements, usually with devices installed around the city (inductive loops, ANPR cameras, etc.)
2. External measurements, usually not targeted solely for the cities. Examples of these kinds of measurements are travel times by a vendor such as TomTom, statistical data gathered by a statistical bureau, and more.

The provision of information to the public is either information on the status of services (a diversion of the bus line due to maintained works for instance) or the promotion of some (sustainable) transport options. Accordingly, city service or data provision alternatives are threefold.

1. The city may develop the means of service by itself. E.g. Graz provides journey planning services on its website.
2. Joint development of a service with specific transportation firms in the form of PPP (Public Private Partnerships). An example can be VMZ Berlin through the traffic management center which disseminates traffic information to the public based on municipal devices.
3. Providing the public with the fundamental data required to develop an information service. For example, provision of a dynamic table listing car-sharing rental stations.

While there are hundreds of cases following the first point, only a handful are relying on open data to follow the third approach. The UK had planned to release open data rail and bus information by April 2012. In France, an open data project named "Datalocale" was launched in July 2011 in the Gironde and Aquitaine regions. The French railroad company (SNCF) also plans to open its data. A known initiative for making transportation data available was made in London within the framework of Transportation for London (TFL), which opened its databases for developers in August 2011, or in Manchester, which also started an open data project. Another German project called Mobilität Daten Marktplatz is also committed to the distribution of transportation related information. The operational phase of the project is planned to take place in 2013. Another European country that is making progress in this field is the Netherlands, with their National Data Warehouse project, that commenced 2007 with the aim to create a joint database for traffic data, which will be made available for developers. In contrast to these initiatives, some authorities are reluctant to move in this direction. The open data approach is not specific to transportation but concerns all government data, and is therefore likely to enable further integration between activities in the public authorities.

3.3.11 ***Data Generation***

When reviewing data generation sources, three types of devices should be considered: devices installed in the infrastructure, devices installed on the vehicles and devices carried by humans.

3.3.11.1 *Intrusive Installation Detectors*

When using sensors as a means of collecting traffic data, a rough division can be made between intrusive methods such as pneumatic road tubes and magnetic loops, and non-intrusive methods including passive and active infra-red sensors, microwave radar sensors and ultrasonic and passive acoustic sensors. Both methods are commonly used in many different cities. Wireless sensors installed on the road can be used for generating traffic data as well as parking data. Its main advantage is the relatively easy installation and maintenance required, compare to conventional in-road magnetic loops. Such detection devices can be found in signalized junction in Kaunas (LT), Blackburn (UK), in loading bay area in Belfast or as data collection devices like in Paris.
Pedestrian and cyclists counts are not as common as vehicles counts; however several cities are performing such count using various technologies. EcoCounter supplies several types of detection technologies among which the Eco-Totem system, which is based on the ZELT loop. The ZELT loop precisely analyses the electromagnetic signature of each bicycle wheel, with 13 differentiation criteria. Copenhagen and Luxembourg installed this system. This technology was also chosen for monitoring the availability of on-street parking places by the Spanish municipalities of SantCugat and Barcelona. In Nice, France, the project involves the installation of U-Spot parking sensors. By detecting magnetic field disturbances and changes in the lighting level, these sensors detect and report available parking space.

3.3.11.2 *Non-intrusive installation detectors*

Automatic video detection is used for gathering data on vehicles in two ways. The traditional use of this type of devices is to superimpose detection zones on the video image. Such devices are installed, for example, in Birmingham and Leicester for vehicle detection required for SCOOT traffic management. Video detection is also used for pedestrians' counts. One example is the technology of Springboard's electronic that has been adopted by a number of towns within the South Yorks region.
With the large number of mobile devices that include Bluetooth communication, a new type of detectors is developed based on capturing the transmissions of such devices. Using this technology within the urban network has to take into account the nature of such networks, in which junctions are relatively close to one another.

3.3.11.3 *Devices installed on the vehicle*

Certain types of vehicles (taxis, buses, cargo fleets) are often equipped with GPS devices, which have a relatively high accuracy. Taxis, buses and cargo fleets are common examples of such vehicles. The Copenhagen Wheel is a device attached to bicycles. Its functionality is twofold. It transforms ordinary bicycles into hybrid electric-bikes with regeneration and at the same time has real-time environmental sensing capabilities. While riding, the wheel captures pollution levels and traffic/road conditions.

3.3.11.4 *Devices carried by travelers*

Mobile phone ownership is very high. These probes are valuable sources of information, and require no installation. The accuracy achieved by identifying mobile phones' cells is not as high as the accuracy provided by GPS devices. However, the amount of probes can compensate the level of accuracy. In addition, the cellular data is sometimes fused with other types of floating car data, such as data originated by GPS-based commercial fleets. Authorities procure data from traffic information providers both for real time traffic management tasks and for medium and long term planning.

Smartcard interfaces could be "Contact Smart Cards" that obligates direct contact of the card with the reader and "Contactless Smart Cards". The city of Bremen offers Contactless Smart Cards as well that combines use of public transport of different operators, car sharing services, banking, and tourist attractions.

3.3.12 ***Travel Planning***

A multimodal journey planner (JP) is an IT system able to propose a set of one or more transport services answering at least the question "How can I go from location A to location B at a given departure/arrival date and time under which conditions" [EC, 2011]. The common points of access to journey planners are via a specific web site or a smart-phone application. There are currently more than 100 journey planners in Europe.
As a consequence of the large number of existing journey planners and of their on-going upgrading process it is practically impossible to review all existing journey planners.
In mid-2008, as part of WISETRIP, 25 state-of-the-art journey planners (22 European and three non-European ones) were reviewed, and characterized according to the following functional attributes: modes covered, type of information provided, criteria to calculate itineraries, other content and features, medias for accessing the information.
The challenge is to integrate data from various sources into the journey planner, representing different modes, and to provide information on this base. In-Time is a commonly agreed interface which enables standardized access to local RTTI services and information provided by Regional Data/Service Servers (RDSS) in any city or geographical area implementing In-Time. By using the In-Time access layer, TISPs are able to access local data and services via a standardized interface bundling all transport information in the area, and exploit these to offer enhanced services to the road and transport end user. The In-Time interface has been adopted by some cities including Vienna.

Car sharing, car-pooling and demand responsive transportation have not yet been practically integrated into journey planning.
In terms of information provided to the travelers, distinction should be done between information essential for conducting the journey (such as bus line number etc.), and auxiliary information. Usually, the most essential information is given for each journey plan alternative. Information specifically calculated and presented for each travel alternative is more valuable and is sometimes available. This is the case for instance with the British journey planner PlymGo, which also presents calculated emissions, calories and duration for each alternative.

Other journey planners provide parking availability information (such as by AnachB), but this information is not integrated into the journey planning search engine. TranzMate is a

new Israeli journey planner for public transportation that fuses real-time information provided by the travelers into the application. Travelers can report not only about delays in public transport and crowded public transport vehicles but also grade the behavior of the driver and the inspector. These features have a potential to improve the overall level of service of the public transportation.
The ability of journey planners to provide personalized information is the next major challenge, currently addressed by several projects.
As journey planners are complicated systems, some complementary applications, focusing on specific tasks and populations, are being developed. Pedestrian navigators in general, and especially for the disabled, are probably the most important type applications that are essential for enabling multi-modal mobility for the entire population.

3.3.13 ***Charging Ticketing and payment***

Mobility related charges can include public transport fares, parking, mobility services such as public bikes, congestion and infrastructure charges, etc. Considering that a key challenge is integrating public transport ticketing systems locally and that the number of transactions for public transport is by far the greatest of all payment of mobility services, public transport is driving this integration of ticketing and charging services.

Booking of transportation services requires a unified approach towards fares and payment methods. The “Interoperable Fare Management” project (IFM) aims specifically to make the access to public transport networks more user-friendly by facilitating their accessibility. The goal is to create an Interoperable Electronic Fare Management (IEF) in Europe that permits customers in public transport to travel barrier-free and without ticket limits from "door to door", this can be achieved by a Europe-ticketing application, which will realize, both electronic tickets as well as different payment methods, to charge service in travel. Several tickets technologies are available today which are all backed up by general e-payment systems.

3.3.13.1 *Near field communication (NFC)*

According to [Wikipedia, 2012] Near field communication (NFC) is a set of standards for electronic devices to establish radio communication with each other by touching them together or bringing them into close proximity, usually no more than a few centimeters. Many of the existing smart phones are already NFC enabled thus fulfilling a major part of the NFC eco-system. The Nice-area (FR) operator Veolia Transport enabled riders to pay and download public transport tickets, either as 2-D barcode or to the NFC application stored in the SIM. The payment for these tickets is made through the phone bill, and the validation is made on the bus. As NFC is a two-way communication protocol, travelers can access trip-related information during using the same NFC application. In Frankfurt operates the NFC HandyTicket service with more than 2.000 NFC tags at stops and stations.

3.3.13.2 *Smartcards*

Smartcards can be used for advanced pricing models and integrating different operators and modes of transport into the same fare system. Using Smartcards travelers can be charged the cheapest price according to length of a trip, time of day or number of journeys as smart-ticketing can be used to automatically provide the user with the most suitable fare for their travel, including fare-capping. Smartcards have a unique serial number and can provide information about travel behavior and habits of passengers (how and when people travel), which allows customization of public transport service to suit actual travel needs.

Smartcard interfaces could be "Contact Smart Cards" that obligates direct contact of the card with the reader and "Contactless Smart Cards". The city of Bremen offers Contactless Smart Cards as well that combine the use of public transport of different operators, car sharing services, banking, and tourist attractions.

3.3.13.3 *Integrated credit card payment*

Another method of payment is using credit or debit cards. Stagecoach group in the UK allow passengers use contactless bankcard payments on board buses using “tap and go” Technology. The technology allows travelers paying for their trip by tapping their debit or credit cards on scanners. This technology is commonly used in the United States and New Zealand. Transport for London is adopting VISA and Mastercard contactless bankcards as a means of paying for transport services within London, with no ticketing involved other than reading the card and fare calculation will take place overnight in the back office and not involve the card itself. By adopting the contactless bankcards, it is expected that the costs involved in distribution of the Oyster cards will be reduced.

3.3.14 ***Social Network***

Social networking is defined in the dictionary as the use of Web sites or other online technologies to communicate with people and share information and resources [Dictionary reference, 2012]. Nowadays, most of the social networks are also reachable through mobile applications, and many of them use location-based information as an auxiliary feature. Their distinct characteristic is that the resources are owned by the members of the social network and passed among them.

3.3.14.1 *Transportation-related social networks*

Transportation-related social networks can be divided into two main categories: Social networks based on mutual needs and Social networks based on complementing needs. Social networks based on mutual needs are used to share both transportation-related information and transportation services. Information is usually shared by travelers using similar transport modes.

Here is a list of social networks illustrating their use for urban transport:

- WAZE is a social network of drivers that share information regarding traffic.
- Cyclists’ social networks, such as Morvelo.cc, are emerging. Ealing Cycling, which is the Ealing branch of the London Cycling Campaign promotes cycling as a sustainable transport alternative. The mobile application MapMyRide, enables real-time tracking of routes taken and sharing this information with a group.
- FixMyTransport was built to help people get public transport problems such as persistently broken ticket machines, buses that always leave early, or silly rules resolved.
- The Norwegian transport company Kolumbus has embedded 1,200 bus stops with QR codes that provide real time information about upcoming buses, after scanning

them. In addition, thanks to the project "Tale of Things", PT users can leave messages for one another. Thus, the bus stop becomes a node for a social network.
- Carpooling.com is a social network application offering services in nine European states such as UK, Germany, Italy and more. In the case of Stuttgart, the municipality itself initiated a car-pooling social network, especially oriented towards commuters in the Stuttgart region.
- WhipCar is one of several examples of social networks through which members are renting each other's car when it is not in use. Other social networks focus on member renting private parking places to other members of the network, such as in ParkatmyHouse.
- Plugsurfing UK provides information about over 12,000 public and private charging stations for electric vehicles in the UK and the whole of Europe, and enables the networks members to contribute by adding more stations.
- bring.BUDDY is an innovating attempt of a student team at the School of Design Thinking, Potsdam in cooperation with the DHL Innovation Center to use complementing needs of people for sustainable logistics.
- Green City Streets is an integrated set of Web 2.0 applications designed to help members of the social network make transportation in the city more sustainable, including through the use of games.

3.3.14.2 *General purpose social networks*

General social networks are mainly use by transport authorities and operators to provide information to travelers, for instance through their twitter accounts. The potential of these networks as a source for understanding people's mobility needs and for providing them with useful transportation-related information is only in its very early stages. Several projects such as SUNSET [SUNSET project, 2012] are looking at this.
As social networks were primarily created by groups of individuals, and not by authorities, they reflect the needs and preferences of these individuals. The engagement of authorities into these organizations, aiming to promote transportation policy goals, is just starting to emerge.

3.4 Legal and regulatory framework of relevance

The legal and regulatory framework of relevance is related to the following topics:

Procurement

The procurement of ITS services and systems is sometimes challenging and preventing the public authorities to reach their objectives. The lack of flexibility in the regulation or appropriate framework for the procurement of innovative systems could be a barrier. It is therefore interesting to understand for instance whether ITS procurement is supported by an innovation programme, and how the directive on public procurements is applied in a specific local context.

Intellectual property

Proprietary systems are commonplace in ITS meaning that use of the technology for purposes other than those stated in the contract/licensing agreement is rarely permitted. Ownership issues must also be dealt with when technology is upgraded in project implementation

Liability

Liability applies mainly to in-vehicle ITS; however, the advent of cooperative V2I means that this issue will need to be addressed, notably in terms of who is liable if the wrong information is given (inaccurate speed limit, inaccurate route guidance, inaccurate digital map).

Privacy

The main concern pertains to the ability of ITS to track and record vehicle and people movement without the consent of the traveler, notably through systems such as road user charging, speed limit violations, Smart Cards (for public transport), etc. To alleviate such worries, legislation can be used (e.g. restricting use of information gathered through ITS such as images captured through CCTV) and data can be stripped of personal information by making it anonymous (e.g. removing bus drivers identity from vehicle identification, removing personal data from floating vehicle data use for traffic management, removing passengers identity from Smart Card data used to build O&D matrices used for transport planning purposes). Nonetheless, the prospect of external attacks (hacking) are an ongoing concern and must be addressed. The current trend towards publishing data (open data) will undoubtedly put privacy in the spotlight once again.

3.5 **ITS deployment challenges**

The following chapter will show that the main challenges for deploying ITS are not technical. The development, adoption of ICT infrastructure and ITS is an on-going process which needs to address several challenges. In the questionnaire circulated to cities, six challenges were defined with the option to add more. The six challenges defined, form the categories in Figure 15. Besides these categories only Vienna mentioned the lack of trained and professional staff as an additional challenge. Each of the cities was asked to rank the importance of answering the challenge as it perceives it. Seven ranks were defined where 1 was defined as the challenge of major importance, and 7 as the least important challenge. It should be noted that challenges which were defined by the cities with the lowest importance are so only in comparison to the others.

3.5.1 ***Organizational/institutional issues***

3.5.1.1 *Cross-boundary collaboration*

ITS cuts across policy boundaries within a local (transport) authority as well as across different public bodies (local authority, public transport operator, transport police etc.) and more recently between the public and the private sector. Effective ITS deployment requires collaboration between council departments and other bodies within a city as well as between the different levels of government (local, regional and national). This is not commonplace many reasons, for instance, the different institutional cultures, the competition for public funding and generally the lack of a strategic approach to ITS needs assessment and deployment.

3.5.1.2 *Operational matters*

Silo systems: ITS is implemented and operated by different departments and agencies within a city without any coordination or consultation. The bigger the city, the more complex and fragmented are the ITS applications deployed. In many cases, there is no clear overview of ITS implemented within a city. Data is gathered and held by several different stakeholders and in many cases it is not shared between the relevant departments and agencies, meaning that the full potential of that data is not exploited.
The effectiveness of ITS depends on how they are implemented and operated. This is rarely considered by local authorities. Skills (technical expertise and training) and staff retention are important issues. Data has no value unless it is processed in a meaningful way (requiring the right equipment and trained staff)

3.5.1.3 *Risk aversion of local authorities*

Local authorities are rarely the first (nor the second) to use new technology. They prefer tried and tested solutions, especially where large investments of politically risky ITS-enabled measures are concerned. London for instance selected a basic technology, ANPR, for enforcing its congestion charge. This technology is expensive to install and operate, transaction costs are high and the technology is not 100% reliable (a small percentage of vehicles are not captured by the system). However, it was considered better to go with a low-tech solution rather than running the risk of technological failure for such a highly politically sensitive

3.5.2 ***Technical challenges and barriers***

3.5.2.1 *Interoperability*

The lack of standards within the ITS industry has led to a situation of vendor lock-in for local authorities across Europe, meaning that a local authority is tied to a particular supplier for ITS procurement because ITS components from different suppliers cannot work together. This makes it difficult to achieve economies of scale among local authorities and it reduces the scope for innovation within the ITS industry. The lack of interoperability has been raised by local authorities in many countries across Europe. Several countries have already developed open specifications and standards for traffic and wider ITS: these include the UTMC initiative in the UK and the OCIT/OTS specifications in the German speaking part of Europe. Many local authorities have adopted some of the specifications and evaluations have shown real cost savings (60% cost savings on traffic controllers for instance). The concept of open specifications and standards in traffic control and wider ITS will be promoted through Europe through the European project POSSE.

3.5.2.2 *Legacy systems*

In the recent years, cities have made huge investments in ITS implementation, especially in their UTC (urban traffic control) systems (traffic controllers, traffic control system hardware and software, traffic control center, etc.). Further ITS applications have been installed progressively and a systems' architecture has gradually been built up. Local authorities have repeatedly stated that new technologies (such as cooperative system) can only be introduced incrementally (for cost reasons) and must adapt to the existing ITS framework.

3.5.3 ***Financing ITS***

Funding ITS is one of the main barriers to deployment. Transport managers must compete with other council departments such as education and social services for the transport budget. Within transport, ITS must compete with physical infrastructure investments too (road building and maintenance). ITS requires considerable funds to operate and maintain ITS (control center, gather data, dissemination info, hardware/software purchasing/repairs, performance monitoring, databases, communication, contract management, etc.). These revenue costs are higher for ITS compared with road building projects. Previously, revenue costs were not given enough consideration when procuring ITS (mainly the capital cost was considered). This is changing given the considerable communication and transaction costs for some ITS.

3.5.4 ***Policy issues***

3.5.4.1 *Strategy*

Absence of a strategic approach to ITS – few (if any) cities have an ITS strategy or have undertaken an ITS needs assessment. ITS is therefore implemented (and funded) in an ad hoc manner which leads to the fragmented deployment of ITS and operational silos.

3.5.4.2 *Impacts assessment/understanding performance*

Where assessment is undertaken, it is often in terms of outputs (ITS deployed) rather than outcomes (impacts and cost-effectiveness). ITS is often assessed in terms of:

- Outputs, such as the number of adapted traffic signals, the number of CCTV, the number of bus stops offering real-time passenger information, etc , and/or
- Short-term effects such as a reduction in carbon emissions, reduction in travel time for vehicles or the increase in the commercial speed of buses. These short-term effects will have longer-term (1+year) impacts but these are rarely assessed. For instance, a measure to smoothen traffic flow in a city center in order to reduce tail-pipe emissions may well be successful in the short-term. However, unless certain demand management measures are implemented, traffic volume may well increase in the longer term and emissions will go up again.
- a single transport policy objective (traffic efficiency) rather than the full range of transport policy objectives (pollution reduction, road safety, social inclusion)

The lack of an evaluation culture in ITS (as described above), combined with the technical nature of ITS, means that it is not always easy to 'sell' ITS to decision makers. It is therefore important to explain ITS in terms of expected contribution to local priorities and policies, such as modal shift from private car or journey time reliability for instance.

Policy goals can influence deployment: Where economic growth is a priority for an administration (e.g., in times of recession), infrastructure building and job creation often take precedence and money is directed there accordingly, to the detriment of ITS investment.

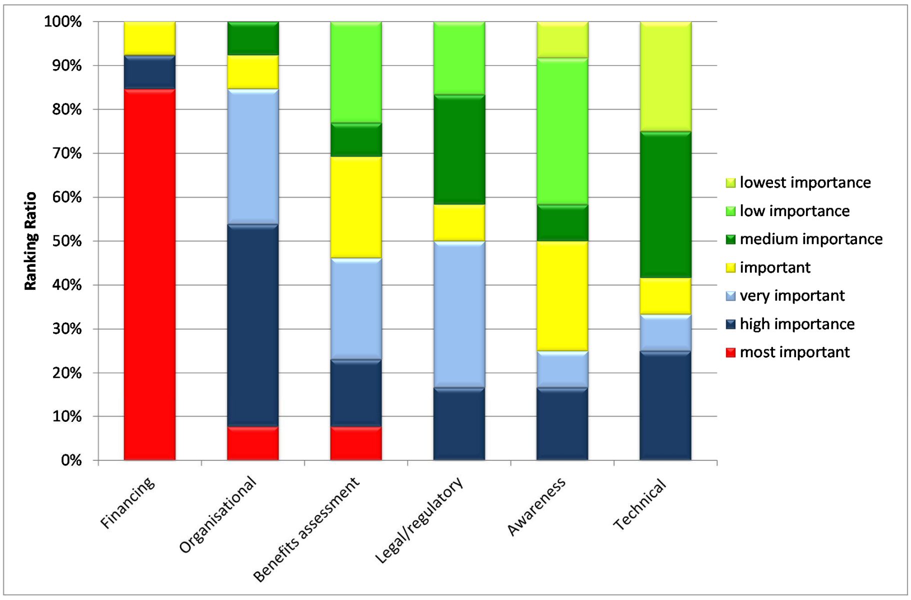


Figure 15: Barriers to ITS deployment

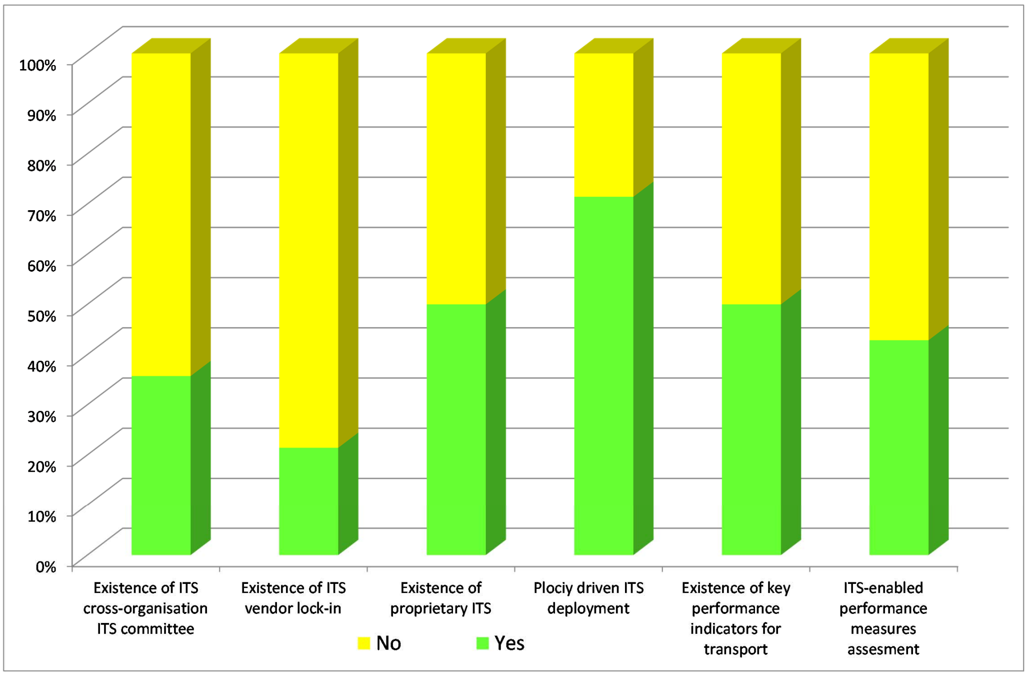


Figure 16: Legal and Regulatory

4 Identification of emerging ICT concepts for optimizing mobility in Smart Cities, scientific and technological impacts

4.1 Introduction

Smart City can be defined as the use of information and communication technology to sense, analyze and integrate the key information of core systems in running cities. In the Smart City, digital infrastructure will improve the efficient use of the physical infrastructure. People's mobility in a Smart City is supported by Intelligent Transport Systems (ITS) which collect real time data by using remote, fixed and vehicle sensors (floating car data). They aggregate and process information either by utilizing local units or cloud services and disseminate it via dynamic message signs, radio (TMC messages to navigation devices) or other media (internet).

The chapter begins with an inventory of ICT technology trends (Chapter 4.2) and continues with a summary of emerging ICT services for smart, clean and efficient urban mobility and related service bundles (Chapter 4.3). Detailed descriptions of services and service bundles are provided in ANNEX C – Examples of emerging services. The impacts of ICT technology trends on the development and deployment of emerging services are then described in Chapter 4.4. The results of the technological assessment are presented together with the results of the next chapter (Assessment of social and economic impact and benefits of new emerging technologies) because the assessment methodology was essentially similar to the method used.

In general, ITS and ITS services are essentially based on technologies and solutions originally developed for other purposes and borrowed from other fields of technology such as computing, data communication, microelectronics and advanced materials. For this reason, the impact of ICT technology trends on the development and deployment of emerging ICT services for urban mobility can be understood better when a detailed inventory of ICT technology trends is carried out and descriptions are provided for individual services to be analyzed.

4.2 ICT technology trends

4.2.1 *Overview*

The common technical architecture for ITS and Smart City includes the following layers (Figure 17) [Suo2012]:

- Perception layer: obtains information of all components of the infrastructure with sensors, actuators, tags and readers
- Network layer: enables the data transmission between sensors and actuators and the application support layer by using either wired or increasingly often wireless connections
- Application support layer: provides massive data processing capabilities by using cloud computing
- Application layer: analyze and process data related to environmental monitoring and intelligent transportation

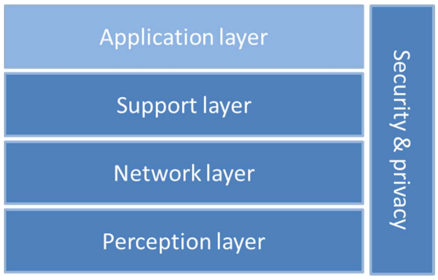


Figure 17: A technical architecture for ITS and Smart City

The presentation of this study follows up this architectural model. Key technologies related to each non-application-related layer are examined more closely and some forecast for the near future developments are expressed.

The Smart City and ITS concepts are both highly dependent on energy-efficient sensing and processing technologies enabled by advances in semiconductor technologies. Since all the future components and mobile devices are affected by energy conservation needs, an overview of battery and energy harvesting technology trends are shortly introduced in the same context.

Perception layer technologies consist of smart sensors, machine to machine (M2M) communications and Internet of Things (IoT). The Smart City concept utilizes various environmental sensor technologies, but from the mobility point of view the most important one is the ability to determine the location of humans and vehicles, so positioning technologies are covered more closely. Future Internet is a general term covering all research activities on new architectures for the Internet. In this study the relevant parts of Future Internet development are related to wireless and sensor networks. These topics are investigated in the "Network layer" chapter but some part of technologies related to sensor networks are also discussed in the "Smart Environment".

4.2.2 *Trends in basic ICT technologies*

Processors

During the next few years (beyond 2013) it's estimated that transistor counts and densities will double every 3 years. This "relaxed definition" of Moore's law is expected to be valid till 2020 but several key technologies related to semiconductors and consequently their use will encounter remarkable changes [Izydorczyk2010]. For the next decades processor's performance increment is expected to be 30 times (by 2020) but this will need some significant refinements in processor technologies. The limiting factor is energy consumption, so added up parallelism, accelerators, heterogeneous processor cores and tighter software-hardware partnerships are required. The evolution of mobile application processors follows the same path as microprocessors. For the next ten to twenty years processor performance will still increase substantially in accordance to Moore's law but achieving it will be much harder. Some emerging new technologies beyond CMOS like compound semiconductors & carbon nanotubes are under investigation but these basically have the same scaling challenges as silicon based technology [SciAm2010]. The application of quantum mechanical phenomena such as superposition, entanglement and nano/synthetic-biology based bio-computing utilizing biologically derived molecules, such as DNA and proteins for calculations [Kroeker2011], are still in their infancy and won't be commercially viable for mass production until the next ten to twenty years.

Memory technologies

Memory consumption has increased steadily, following CPU processing power advancement. Power consumption, in both mobile and data center (cloud computing) applications, is becoming a real issue. Memory performance is forming a bottleneck that limits system performance in critical applications that become more data-centric and less compute-centric. Instant-on becomes a basic requirement for many commercial applications - especially in mobile devices. NAND-based flash technology will reach its limits before 2020 due to the fundamental physical limits (floating gate interference, short channel effects etc.). Researchers [Grupp2012] estimated that NAND-based SDD (solid state drive) drives might become too slow somewhere around 5TB, when access delays will increase sharply. There are several alternate competing technologies available to replace NAND-based flash memories [Kyder2009]. The most prominent in respect to energy efficiency, access time, endurance and retention is PCRAM and STTRAM (Spin Transfer Torque RAM) (Table 10).

Type	SRAM	DRAM	NAND Flash	STTRAM	PCRAM
Maturity	Product	Product	Product	Prototype	Product
Current Density/chip	Theoretically ~1 GB (in practice 1-2 MB)	8 GB	64 GB	2MB	512 MB
Access time (write/read)	1 ns/ 1 ns	10 ns/ 10 ns	200 µs/25 µs	10ns/10ns	100ns/20ns
Endurance/ Retention	10^{15}/-	10^{15} /64 ms	10^{5} /10 years	10^{15}/10 years	10^{5}/10 years

Table 9: Comparison of current and fore coming memory technologies

In the year 2020 it is expected still to have HDDs as well as NAND-Flash memories available (having multi-TB capacities) as the main commercially viable and non-volatile memory technologies. Beyond that, some new technologies like PCRAM and STTRAM might take the dominant place.

Display technologies

Currently, the dominant display technology is LCD (Liquid Crystal Display) that uses the light-modulating properties of liquid crystals (LCs). OLED (Organic Light Emitted Diode) is a LED technology that uses organic carbon based films bonded between two electrodes. Micro electro mechanical systems (MEMS) refer to mechanical nano-scale technology utilization [Liao2009]. Some current devices like Amazon's Kindle offer monochrome displays (called e-paper) that is based on electrophoretic technology. Display technologies will follow up the general trends of other semiconductor technology areas during the next years. Scaling (increasing display pixel density) and energy efficiency are the main driving development forces. Since OLED displays can be constructed on a flexible substrate, this enables lighter and more rugged displays in the next few years that can be curved or even rollable. Another future trend is the combination of different display technologies for outdoor and indoor use that are easily distinguishable in all lighting conditions. Since the manufacturing cost of large displays are decreasing fast, very big, low-power and high-visibility displays are emerging into signage and billboard use. Flexible displays will experience a fast growth in the next several years, but they won't become truly main stream before 2018 due to technical problems and higher manufacturing costs compared to traditional glass based displays [Geller2011].

Cloud computing

Cloud computing is a paradigm where data and services reside in massively scalable data centers and can be ubiquitously accessed from any connected device via Internet [Armbrust2010]. Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can rapidly be provisioned and released with minimal management effort or service provider interaction [Mell2012]. Cloud Computing refers to both the applications delivered as services over the Internet and the hardware and software in the data centers that provide those services [Armbrust2009].
Gartner predicted that mobile phones will be the most common Web access device worldwide in 2013. The Mobile Cloud Computing (MCC) paradigm intends to make the advantages of cloud computing available for mobile users as well7. Mobile cloud applications can be deployed in different ways. Downloadable cloud applications are available from application stores like current mobile applications, but instead of using local resources only, mobile could applications use cloud services like storage, computing power and mash-up APIs etc. (Paas and IaaS). Web based cloud applications (e.g. SaaS) are solely based on browser capabilities and browser abilities to utilize mobile devices' resources (like ability to access GPS data etc.) and mobile devices act more like "thin clients". Mobile cloud computing seems to be the ideal way to extend phone capabilities and services. Smartphone operating system manufacturers like Google, Apple and Microsoft are also integrating their operating systems more tightly to environmental services like maps.

4.2.3 *Trends in Smart City technologies*

Wireless communication

Currently most widespread wide area mobile communication technology is Universal Mobile Telecommunication System (UMTS), based on CDMA (Code Division Multiple Access) access principle. The initial release of UMTS was back in 2000 and since then it has undergone many evolution steps. LTE (Long Term Evolution) initiated in 2004 is the enhancement of UMTS. Mobile broadband subscription counts are rapidly increasing and users will generate large amounts of data traffic on mobile networks by using Internet type applications. Future mobile traffic will increase most dramatically due to entertainment services like music and video (e.g. streaming type services). Another source of tremendous mobile data traffic growth is M2M (and IoT) applications. Cisco [Cisco2012] estimated that

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[7] Mobile cloud computing can also mean mobile device clouds e.g. mobile devices in a cloud in a more active role (simultaneously in the client and the server role) rather than only utilizing a pool of servers. In this study we are not covering this approach.

global mobile data traffic will increase eighteen-fold between 2011 and 2016. By the end of this year (2012) the number of mobile-connected devices will exceed the number of people on earth, and by 2016 there will be over 10 billion mobile-connected devices including machine-to-machine (M2M) modules—exceeding the world's estimated population at that time. Over 4 billion devices will be IPv6-capable in 2016. At the same time span, the average mobile network connection speed (189 kbps in 2011) will increase to nearly 3 Mbps in 2016. Unfortunately current mobile network architectures are not well prepared to cope with new wave of mobile data. However, traffic volume increase is inevitable and the future network architecture evolution has to be optimized to cope with it.

Location technologies

The most well-known and most used system is the Global Positioning System (GPS) that was originally designed for military use but released also for public use free of charge. GPS is under an on-going modernization program. Augmenting the GPS signal with external information can significantly improve accuracy. In addition, the high-accuracy RTK-GPS, providing centimeter-level accuracy, currently used mainly in land survey and hydrographic survey, has been studied in order to utilize it in larger use [Usui2004].

The Russian GLONASS complements and provides an alternative to the GPS and is currently the only alternative navigational system in operation with global coverage and of the same precision. While GLONASS did not yet gain popularity in the consumer markets there are already signs that GLONASS may become an alternative or a complementary positioning system for GPS. For example MTS and Sony Ericsson added GLONASS support in their phones. [MTS 2011, Padre 2012]

Europe's own global navigation satellite system, Galileo, brings yet another civil alternative to the market providing a highly accurate, guaranteed global positioning service under civilian control. Current estimation is that Galileo will not reach full service until 2020 at the earliest [Selding 2011], which means that GPS will be the major satellite positioning system in the time range of this study.

Above these three global satellite navigation systems there are also other systems emerging, e.g., The BeiDou/Compass Navigation Test System (China), Quasi-Zenith Satellite System (Japan) and Indian Regional Navigation Satellite System (India). GNSS augmentation is also not restricted to the ones introduced earlier in the GPS context. [Hegarty 2008][Hofmann-Wellenhof 2008].

Mobile phone location determination or cellular positioning has been proposed to serve as a universal positioning technique for inhabited areas where the mobile phone penetration is high and infrastructure is almost ubiquitous. Several different techniques for cellular positioning have been proposed. Some of them require too much infrastructural investment while some others would require significant changes to the existing terminals.
In academia, the fusion of several different positioning techniques and sophisticated data processing has been a popular topic for a long time. The results have been applied, e.g. to the navigators and mobile phones that are currently in large use. It can be seen that solutions that use multi-constellation GNSS receivers and many other positioning techniques will emerge to support ubiquitous positioning that is sufficiently accurate for most of the services.

The underlying core element that is essential for Geographical Information System is the Spatial Database System that is optimized to store and query data related to objects in space, including points, lines and polygons. The most significant standardization body for the management of geospatial information is the Open Geospatial Consortium, Inc.® (OGC). This is a non-profit, international, voluntary consensus standards organization that leads the development of standards for geospatial and location based services.

Smart Grids

A Smart Grid can be understood as an ecosystem of energy production and consumption which heavily utilizes ICT technologies to achieve greater efficiency than its traditional counterpart (Karnoukos 2010). Traditionally energy supply was adjusted to meet customer demand. Smart Grid technologies, for example, allow the network to control loads connected to the network, interact with systems providing the Grid with energy and monitor the status of the network in a more sophisticated way.

Machine to machine communication and Internet of Things

Internet of Things (IoT) can be seen as a generalization of M2M (machine to machine communication). Technical advances decrease the costs of sensors, actuators and processors allowing them to be utilized in any real world objects. Internet of Things refers to everyday objects that are readable, recognizable, locatable, addressable, and/or controllable via the Internet (via RFID, network or other means). In the IoT-vision these spatially distributed smart objects with sensing and actuation capabilities will become a part of the Internet and will be able to communicate with each other or humans, enabling a whole new class of applications and services [Miorandi2012, Atzori2010].

The main building blocks of the IoT concept are RFID (NFC, Near Field Communication), Wireless Sensor Network (WSN) and new Internet Protocols. The main challenge to implement the IoT vision is to put these technologies working together. Despite the initial skepticism of many researchers about the suitability of the Internet architecture to sensor networks and IoT, today the general trend is to move towards the use of IP.

To enable higher level communication with WSN motes, the Constrained Application Protocol (CoAP) is defined by IETF (work started in 2010) to enable web services for even the most constrained devices and networks. This protocol is still under development. The question is how fast these standards will be adopted. There are several technological areas that need further research and development. Another central issue of the Internet of Things will be trust, privacy and security. Over the next 10 to 15 years, the technologies for the Internet of Things are likely to develop fast, but the pace of adoption is difficult to forecast.

4.2.4 *Trends in user interaction technologies*

Multimodal interaction

Humans perceive the surrounding world through their various senses (sensory input) and act on it through the motor control of their effectors. Multimodal interaction is defined as a situation where the user is provided with multiple modes for interacting with a system. The mouse and the keyboard are being replaced by touch and motion based interfaces in mobile phones. This trend is called Natural User Interfaces (NUI). Natural User Interface is used to refer to user interfaces that are effectively invisible, or become invisible to its users with successively learned interactions.
One form of natural interfaces in practice is the use of Near Field Communication (NFC), which is supposed to revolutionize payment, ticketing, and advertising applications. NFC can replace manual typing, menu selections and other user interactions where touching can be applied. The Intelligent User Interfaces (IUI) with different forms of input and output try to help the user in an intelligent manner. Instead of the user adapting to an interface, an IUI can adapt to the user and its environment. IUIs utilize multimodal and "natural" human-computer interaction (e.g. speech or gestures). One step towards IUIs is a context-aware user interface that allows systems to dynamically adapt to changes in a user's task domain by providing relevant information. Despite of the voluminous research work in this area practical solutions are still rare. The only exception is to use the location as a context where application supply is already flourishing.

Augmented reality

Augmented Reality (AR) is a variation of Virtual Reality. VR technologies completely immerse a user inside a synthetic environment so that the user cannot see the real world around. Augmented reality supplements reality rather than replacing it and a user senses that the virtual and real objects coexist in the same space. The information conveyed by the virtual objects helps users in performing real-world tasks.

Mobile augmented reality which comprises the overlay of information on real-world views seen through a mobile phone's camera can be a window to the Internet of Things where real-world objects have data associated with them. Current smartphones already contain most technologies that would enable AR. Various commercial applications have recently been emerging in smartphone markets at an increasing pace like Layar, Junaio, Google Goggles, and Wikitude to name some. Another user interface trend that might turn out to be practically useful in the near future is the head-up display (HUD) currently associated in military applications. HUDs may be utilized in automotive industries as soon as production costs decrease. HUDs are used to display data on the windshield of a car without requiring the user to look away from their surroundings. Recent advances in OLED and other display technologies enable easier display integration to vehicle windshields.

In cars, HUDs are helpful for providing driving-relevant information (for example augmented night vision view. This allows drivers to keep their attention on the road ahead. HUD type data glasses have been developed and used for two decades mostly related to portable computers and military applications. This display technology will mature during the next years due to the recent advancement of display technologies. Even more futuristic HUD displays have been investigated and prototyped.

4.2.5 *Trends in energy technologies*

Battery technologies

Battery technology is crucial to every single mobile device from the smallest portable device to an electric car. Currently and in the near future, Li-ion batteries offer some of the best options for electrical energy storage for high-power and high-energy applications such as transportation and stationary storage.

Zinc-air batteries generate electrical power by an oxidation process of zinc and oxygen from the air. Li-air battery is a derivate from zinc-air and uses a catalytic air cathode that supplies oxygen, an electrolyte and a lithium anode. Energy storing potential is estimated to be 5 to 10 times larger than Li-ion. It might take a decade to commercialize this technology as a rechargeable battery system, but IBM researchers estimate that this technology is commercially viable in 2020. Some others are more pessimistic [Vinodkumar2011]. Another lithium based candidate for the future is Lithium-Sulphur (Li-S) technology. Lithium-sulphur batteries offer energy of 550Wh/kg, (three times the power of a basic Li-ion) and a specific power potential of 2,500W/kg. The current challenges are the very limited life cycle of Li-S batteries and their poor stability at high temperatures. It is expected that material (better electrolytes) and nanotechnology achievements might solve these problems in the future [Vinodkumar2011].

Magnesium (Mg) has also gained attention as a material of high energy density batteries since it is less expensive and safer than lithium. It also has the potential to have twice the energy density of the current lithium-ion batteries. US Department of Defence (ARPA via funding to Pellion Corporation) and Toyota are currently researching this technology but neither of them expects magnesium-ion batteries to be commercially available before 2020.

Super-capacitors store energy in an electric field (static charge) and can't compete with chemical batteries in high energy density applications. Ultra capacitors are enhanced version of super-capacitors. The use of carbon nanotubes in the future might increase the capacitance of ultra-capacitors substantially so that they could be used as energy storage in the near future.

There were great expectations on the fuel cell technology in the 90s but since then the hype around it has slightly diminished. For ICT, the Direct Alcohol Fuel Cell (DAFC) appears to be the most promising as a battery replacement for portable applications such as cellular phones and laptop computers. The problems of fuel cells are low power output, long start-up times, a short service life and high cost. In 2010 the fuel cell industry sector revenues exceeded $750 million, but not a single company is profitable yet [Wikipedia].

Energy harvesting

Batteries have been the most important energy source for embedded and remote system applications where electric network energy couldn't be used. A serious limitation for sensor networking applications is the battery capacity since nodes will operate only for a finite duration e.g. as long as the batteries last. The need for a regular battery change increases costs and operational complexity.

With the limited capacity of finite power sources and the need for supplying energy for a lifetime of a system, there is a requirement for self-powered devices. The solution for this demand is extracting energy from the surrounding environment by using technology called energy harvesting. Energy sources for harvesting include [Paradiso2005, Chalasani2008, Sudevalayam2011]:

- Solar power, which is the most common source. It has the disadvantage of being able to generate energy only with sufficient light conditions.
- Vibrational, kinetic and mechanical energy generated by movements of objects. Vibrations are especially prominent in bridges, roads and rail tracks.
- Thermal energy that uses temperature differences or gradients to generate electricity.
- Electromagnetic energy
- Other more seldom used sources like wind or human's exhalation, breathing etc. for special application areas

There are significant efficiency differences between the harvesting sources as Table 10 indicates [Seah2009]. As with batteries a power density is the amount of energy stored in a given system per unit volume. Duty cycle describes an average ratio of a sleep (passive/idle) and wakeup time (active).

Harvesting method	Power density (µW/cm2)	Harvesting rate (mW)	Duty cycle (%)
Vibration-electromagnetic	4.0	0.04	0.05
Vibration- piezoelectric	500	5	6
Vibration - electrostatic	3.8	0.038	0.05
Thermoelectric (5 deg. Difference)	60	0.6	0.72
Solar (direct/indoor)	3700/3.2	37/0.032	45/0.04

Table 10: Comparison of harvesting methods [Seah2009]

4.2.6 *Trends in information security and privacy*

Predictions show that the mobile cloud market will be valued at $9.4 billion by 2014 already [IBM2011].The growing market also means growing potential for attacks and malicious use. The vulnerabilities of these environments are mostly the same as before with all ICT environments but appended with the ones more specific to (wireless) sensor networks. The growing amount of networked devices – Internet of Things – adds even more and less capable devices to the network. The devices are restricted by their processing capability and energy which makes it hard to secure. The security threats can be divided in three categories: physical threats, mobile network security threats, and malware.

Mobile devices are vulnerable to physical threats. The user may lose some equipment or someone can steal it. Unattended sensors and mobile devices might be modified. These threats can be handled with remote attestation or secure boot mechanisms. Secure booting ensures that all the code from the beginning of the booting process is verified and known to be trustworthy. One key factor could also be the identity of the device.

Internet of Things and M2M communication are becoming similar to sensor networks on the one hand and on the other, to the Internet as we know it today. The growing inequality and heterogeneity is also a challenge. Old IPv4 networks provided some security – or at least defence in depth – by forcing many operators and most home users to use network address translation (NAT) and therefore disabling direct routes between endpoints. IPv6 brings all devices to the fully routable address space which makes it an even more important matter to have adequate security measures.

One key aspect of the change of the networked environment is the fact that critical infrastructure is more and more connected to public networks or the Internet. In the old days, these were normally based upon proprietary and dedicated networks without connectivity or public access. In many cases, the access points of these networks were – in addition to physical securing – in places hard to reach like within the power grid. Both wired and wireless sensor networks have widely been used in critical infrastructure and these are now turning out to be part of Internet of Things which requires thorough assessment of security in these environments [GhaniEtAl].

4.3 Emerging ICT services for smart, clean and efficient urban mobility

One of the objectives of this task was to identify the most relevant emerging ICT services having potential to facilitate smart, clean and efficient urban mobility. The services were then divided into service bundles. A list of services and service bundles is described in Table 11.

The service bundles have been identified on the basis of a literature study which was focused on emerging ICT services for smart, clean and efficient urban mobility. Emerging ICT services were divided into bundles on the basis of the functionalities they provide. Some services within the same bundle may also use common ICT infrastructure. The scope of the work in WP3 including the literature study was originally defined in the work plan of the project and later clarified on the basis of discussion within the project group and results of WP2. The aim in WP3 was also to define the service bundles in a way which allowed both state of the art and emerging services to be classified on the basis of a common framework consisting of the service bundles. Detailed descriptions of individual services and service bundles are provided in ANNEX C – Examples of emerging services.

The rationale for organizing services into service bundles was both to manage the complexity related to a large number of state-of-the-art and emerging services and to allow the analysis of service bundles. The latter was considered necessary because many services analyzed in WP3 and WP4 provide functionalities which are related to each other or are realized in the same usage context or will likely be using the same ICT infrastructure.

Service bundle	**Services analyzed**
Electric mobility services	• Intelligent charging • Electric mobility support services • Urban electric freight
Multimodal mobility services	• Multimodal pre-trip planning • Multimodal on-trip services (Personal travel companion) • Social traffic (Social traffic information, dynamic ridesharing) • New mobility concepts (Incentive-based traffic optimization)
Urban logistics services	• Eco-driving • Dynamic last mile delivery
Urban traffic management services	• Cooperative traffic signal control • Speed management • Dynamic and predictive parking service
Virtual mobility services	• Consumer telepresence
Booking and payment	• Mobile payment • Mobile ticketing

Table 11: Emerging ICT services for smart, clean and efficient mobility and related service bundles

4.4 Impact of ICT technology trends on emerging services

The impact of ICT technology trends on emerging services facilitating smart, green and efficient mobility has been summarized in Table 12. Three marks in a cell refer to a major positive impact, two marks to a significant positive impact and one mark to a case with at least some positive impact.

	Processors	Memory technologies	Display technologies	Cloud computing	Wireless communication	Location technologies	Smart Grids	Internet of Things	Multimodal interaction	Augmented reality	Energy harvesting	Battery technologies	Security and privacy
Electric mobility services													
Intelligent charging				+			++	++				(+)	+
Energy management					+	+						+	+
Multimodal mobility services													
Multimodal on-trip services (personal travel companion)	++	+	+	+	++	+++		++	++	++		++	++
Social traffic information				+	+	+++		+	++	+		+	+++
Dynamic ridesharing				+	+	+++		+	++	+		+	+++
New mobility concepts (Incentive-based traffic optimization)	++			++	++	+++		++				++	+++
Urban logistics services													
Eco-driving	++	+		+	++	++		++	+	+			
Dynamic last mile delivery	++			+	++	++		++					++
Urban traffic management services													
Cooperative urban traffic management (cooperative traffic signal control)	+			+	++	+		++					+
Speed management					+	++			+				
Dynamic and predictive parking service	+			+	++	++		++	+	+			+
Virtual mobility services													
Consumer telepresence	+		++										
Booking and payment													
Mobile payment			+	+				++					++
Mobile ticketing				+	+	+		++					++

Table 12: Impact of ICT technology trends on emerging ICT services for smart, clean and efficient urban mobility.

4.5 **Champion technologies**

The closer look to the example services also reveals the most important enabling technologies that are needed to realize the services (in large scale). Technology aspects that continuously come up include:

- Wireless networks: Especially cellular networks and mobile communications will be in a central role in the service provision to the mobile devices. Here broadband and flat rate pricing will also bring entertainment and infotainment as drivers to the mobile service scene. In the time span of this report the role of short range communications (e.g. IEEE 802.11p) as an enabler for services probably won't be in major role but emerge in the end of period to support V2I communication.
- Mobile devices: smartphones, tablets and other mobile devices provide the most convenient way to interact with many of the traffic related services, especially in multi-modal traffic context.
- Location technologies are central enablers to contextualize services and provide context to collected data.
- Near Field Communications (NFC) will be a central technology in mobile payment and future mobile phones will be equipped with NFC tags and readers. In addition to payment, this technology opens many new opportunities also in other service areas.
- Sensors will be everywhere to observe the environment, provide data and control systems. The envisioned Internet of Things and Machine to Machine related technologies will also emerge to manage the increasing complexity of sensor networks.
- Massive data management will be in the heart of many traffic services that are based on the holistic view on urban traffic. In addition, real-time requirements and spatial computing puts pressure on computing power.
- Cloud computing in its various forms provides solutions for the computing and data intensive tasks.
- Innovative, contextual and safe user interaction is a paramount feature of the services in the traffic context. For that reason, transferring desktop user interaction paradigm to the mobile contexts (e.g., to in-car use) is not usually appropriate. New solutions utilizing, e.g. multimodal and natural user interfaces must be developed.
- Privacy and security solutions will also be under tight inspection as many of the traffic related services can potentially reveal, e.g., users' whereabouts and nature of activities.
- Integration of currently separated services to serve the whole (possibly multi-modal) mobility processes will be one of the key issues of future services.

4.6 Conclusion

The emerging services described in this section zoom to near future revealing some educated beliefs on the development of traffic related services in urban areas. The short time span does not allow dramatic science fiction speculations but services that already exist as ideas, concepts, prototypes, standardization work and experimental services.

5 Assessment of social and economic impact and benefits of new emerging technologies

5.1 Introduction

As part of the Smart0067 study, the different potential or currently advancing technology bundles have been assessed in respect of their various impacts (economic, social and technological). Each of these bundles has a specific technological solution, which aims to provide a selection of services that will be useful and, in commercially viable case, also paid for by the users.

As the technology bundles have been defined in the chapters 3 and 4, the attention turns to the assessment of the impact of the bundles, which were defined (see Table 11). This is important, as some of the solutions are competing against each other, for instance in securing the funding for further development or scaling up, as in the case of future transport and ICT European Large Scale Actions (ELSA). In order to be able to carry out the impact assessment, each service bundle description should contain the (envisaged) technology solutions and a detailed description of the components of the bundle. The concatenations of the various services included, that enhance the impact of the bundle, also need to be described. As far as possible, the costs of producing the bundle should be provided, at least in the format that allows assessment of the commercial feasibility of the bundles as this will have repercussions on the potential to provide broader, national or European level impacts through replication of the technology elsewhere.

The often applied cost-benefit analyzing techniques in transport appraisal will not be suitable for the assessment of impacts. This is due to the uncertainties involved, which will be elaborated below. These uncertainties involve assessment of potential benefits since the penetration is not known as well as declining marginal costs as a result of increased utilization of technologies. Instead, alternative methodology is proposed to allow for comparison and assessment of impacts between various technology bundles.

Regarding the cost-benefit analyses (CBA) of projects, it is natural that under normal conditions for a given project in the transport sector a CBA is carried out. However, the challenge with estimating impacts is that for projects that can be considered to be implemented in various locations across Europe, it is usually clear what the costs are but benefits will greatly depend on the number of implemented projects and their ability to provide impacts beyond single projects through the ability to use similar services outside a region or country borders as well. Assumptions on such processes would require a vision on the actual prospective dissemination of the services and yet analyses would still be at best guesstimates. Problem of such results is that any CBA ratios calculated are likely to be remembered and can create false and debatable pictures of potential developments. Under the prevailing uncertainty such calculations should be avoided.

5.2 Example of a service impact assessment: Personal travel companion

When measuring the economic, social, technological or political impact, there are several levels at which impacts can appear. These impacts can be at national, regional or European level, depending on the coverage and usability of the proposed technology. In the case of emerging technologies it is very difficult to state the exact impact, particularly in monetary terms, due to the uncertainties involved. What is however possible to assess is the magnitude of impact, using a scale that shows the impact, defined as below:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

The use of the geographical scale is based on the idea that a service which can be utilized more broadly in geographical terms has features that provide a greater impact, gain more popularity and increase mobility in broader terms than location-specific services. A score of 1 indicates that the impact is considered to be limited to the city in which the service is being provided. A score of 2 indicates that the impact goes beyond the city limit and concern, for instance, commuters. A score of 3 indicates that a service is likely to be offered at national level and the impact will concern those using the transport system in that particular country, at times also including inter-city traffic. A score of 4 indicates that majority of cities, at least major ones, in Europe will be experiencing the impact of the service. A score of 5 indicates that the service has potential to become broadly adopted in cities globally, similar to availability in Europe. As the numerical scale is not particular useful on its own, it will be accompanied by a description of the impact, which can bring into consideration differences between bundles that have reached the same score. The scale used obviously refers to the potential impact, as city level services will have lower impact than those which can be used at national or broader contexts. The assessment contains also a description of the impacts within the context where the impact is observed so this gives some indication of the relative impact (low, medium, high) in the localized context.

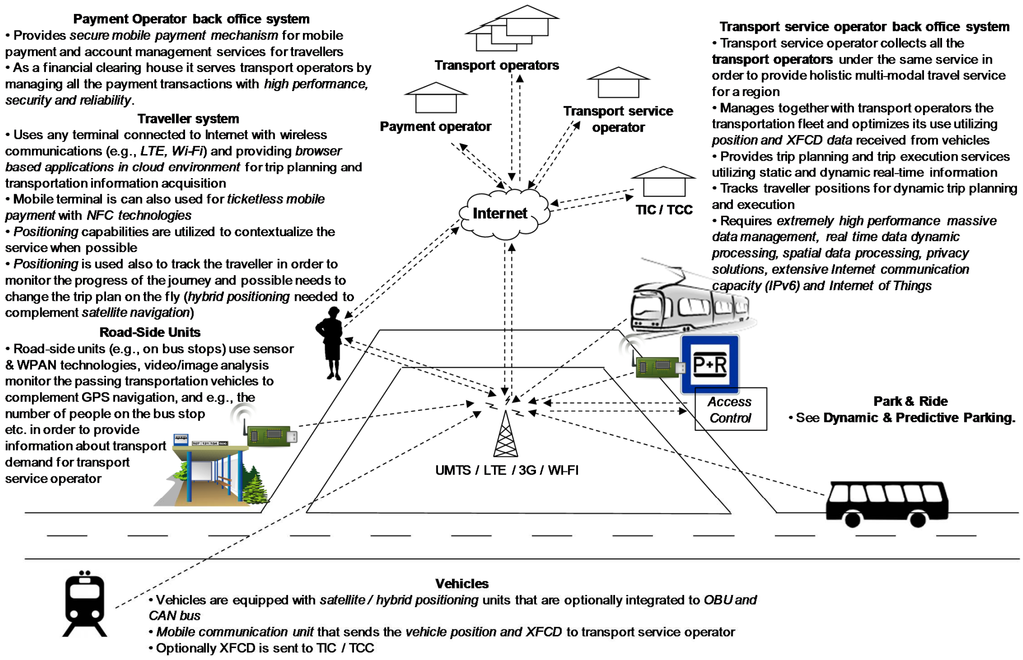

Figure 18: Personal travel companion.

All the services in Table 11 (except consumer telepresence) were assessed in the similar manner.

5.2.1 *Economic impacts*

Service: Personal traffic companion	Magnitude of impact	Description of the impact
Growth	4	There will likely be growth impacts within a city that adopts the personal traffic companion service. These impacts are based on the time savings by travelers from improved route choice and better information of the travel opportunities. This impact can be expected to be similar to impacts of public transport route planners providing similar functionalities (Laine, Pesonen, Moilanen 2003).
Economic competitiveness	2	The size of the growth impacts will most likely be small in national scale so the competitiveness of a city which adopts the service can increase but these impacts do not scale up to regional or national level magnitude.
Economic welfare	2	Welfare gains from improved traveler information and a seamless payment system will be realized in the urban areas where the service is provided. The impacts will depend on transport modes available and covered by service. Socio-economic benefits of the service will be realized at city or regional level.
Investment	1	The services offered will require investments in major data management system, but as the applications will be run at city level, the investment even if done by a national level service provider is considered to affect the city level most.
Market share	4	Due to the investment needed in data management it is likely that at national level a single service provider will emerge.
Overall impact	2 / 4	Most of the impacts associated with the service are of European level, but as there are no major investments associated the overall impact remains slightly below the European coverage. However, the economic impact is one of the biggest among all services evaluated in this report.

Table 13: Economic impacts - personal travel companion

5.2.2 *Social impacts*

Service: Personal traffic companion	Magnitude of impact	Description of the impact
Cohesion	1	The service supports the goal to increase the share of public transport in cities. It also improves the mobility of travelers having no access to a private car. The service likely has a positive impact on social cohesion but this effect will be realized at city level.
Health	1	Health impacts will result from more opportunities to utilize public transport effectively and the associated use of light traffic, however again due to the nature of the service these impacts are likely to remain at city level.
Employment	1	Employment impacts are related to the service set up, no major additional employment impact is foreseen. The data management and interface design will require additional staff resources from the service provider(s).
Quality of life	4	At the European level, the quality of life is likely to increase due to the better information availability on the transport system. This will boost the use of public transport and lead to less congestion.
Service level	4	The service level experienced by users of the transport system will increase and the opportunities to assist tourists and visitors will improve the service provision from the EU point of view.
Greenhouse gas emissions	1	Reductions or slower growth in emissions will result from increased use of public transport however the impacts of the service are likely to remain on city or regional level. Advanced and easy to use information services will be a part of the package of measures required to increase the share of public transport in European cities.
Overall impact	1	The social impact is a mix of city level developments and Europe-wide processes resulting from service level and quality of life improvements.

Table 14: Social impact - personal travel companion

5.2.3 *Policy impacts*

Service: Personal traffic companion	Magnitude of impact	Description of the impact
More Fluid	1	Personal travel companion services that provide information on the progress of the journey and also re-plan trips because of unanticipated events or a change of the traveler's plans can lead to a better urban traffic management due to shorter journey times. There is also potential to reduce congestion if the share of public transport of all motorized trips could be increased.
Greener	1	Personal travel companion services can make public transport more attractive and, therefore increase the use of collective transportation means, which will induce a local abatement of emissions.
Smarter	4	Personal travel companion services through the capabilities provided by future Internet technologies can give multi-modal travel assistance to users, mainly in urban and inter-urban areas. The services can be addressed to travelers for helping them to plan and adjust a multi-modal journey from door to door and in real time; to vehicle drivers for allowing them, for instance, to easily book a parking place or have information about access control in a certain area; to transport operators for providing them with the complete information necessary to initiate demand-driven transportation.
Safer	2	Traveler positioning in fact allows effective localization of any unsafe situation the user can happen to be. The service also allows promotion of safer routes and transport modes. Impacts on the safety and security of travelers are likely to be limited and remain at city or regional level.
More Accessible	2	Personal travel companion services can allow a better accessibility to transport services by easing the way to plan a trip, namely by taking into consideration the traveler's context and preferences, city rules, current requirements and constrains.
Overall impact	1 / 2	The five mobility policy dimensions are addressed to the achievements of a sustainable urban system. The span of impacts is inherently confined into the urban dimensions, possibly regional by taking systematic commuting trips into consideration. By looking at the effectiveness of the bundle on each individual policy pillar it must be pointed out that all of them are positively affected by the delivery of the services;

Service: Personal traffic companion	Magnitude of impact	Description of the impact
		therefore, by promoting the adoption and the deployment of these services to all European urbanized areas, the positive impacts at European scale on the sustainable mobility can be high.

Table 15: Policy impact - personal travel companion

5.2.4 *Technological impacts*

Service: Personal traffic companion	Magnitude of impact	Description of the impact
Innovation	4	The fact that the service can be made available Europe-wide can have innovation potential that spreads across all countries where the service is provided. Benefits will also be extended to those who can utilize the service when visiting these countries. Innovation remains in offering passengers at the European level better real-time travel information in a user-friendly way.
Technological breakthrough	3	Except for the data management, there is no major technology advancement envisaged so the impact will mainly be at the city level. Integration and interfaces for data usage will be needed.
Research competitiveness	3	The service will mostly be based on existing technologies and standards. The deployment of the service will start at city or regional level. Solution providers will most likely compete at national or European level.
Standards agreements	4	In order for the service to become commercially attractive, an interface that can accommodate the systems from various cities and countries would lead to both data format standards and standardized interface design, which would require an agreement on the standard of information provision.
Industrial leadership	4	The development of the service can be expected to follow a pattern which has been experienced with multimodal route planning services. It is likely that regional or national level service providers emerge first and that European level or global stakeholders enter the market after that. For example, Nokia provides multimodal route planning (Nokia Transit) as a service bundled with a smartphone, and Google has its own service Google Transit. At present, multimodal route planning is provided by different stakeholders and on the basis of several different business models (Rapp et al. 2011).
Technological leadership	3	It is assumed that a national level service provider will emerge to ensure the interoperability of the user interface between cities so that the benefits will take place not only in the immediate city context but also during journeys to other cities which operate with same system.
Integration	4	System integration at EU level is needed to ensure a broad user base. This integration can be enhanced by the use of multiple media (phones, internet etc.) for data provision and user-friendly pricing and interface solutions, including roaming costs.

Service: Personal traffic companion	Magnitude of impact	Description of the impact
Knowledge transfer	1	Knowledge transfer is related to the set-up the system as various stakeholders need to jointly agree on the principles and format of data provision to make the system work.
Infrastructure development	1	Apart from the data management system and user interface, no major investments in basic infrastructure are envisaged.
Mobility of personnel	4	The impact should be considered EU-level, if the interface to various national and city level systems becomes standardized across Europe.
Total impact	4	The service has major impacts on utilization of existing technologies and potential to become a truly European level of service.

Table 16: Technological impacts - personal travel companion

5.3 Summary of impacts

The results from the assessments are listed below. The various bundles and services within do differ from each other and this will make it possible to carry out some further analyses. Bundles were defined in chapter 4 on the basis of technologies involved and this classification was also used in the analyses carried out.

	Bundle:	Electric mobility services			Multimodal mobility services				Urban logistics services		Urban Traffic Management Services			Booking and payment	
	Service / Impact	Intelligent charging	Electric mobility support services	Urban electric freight	Social traffic	Dynamic car sharing	Personal travel companion	Incentive-based traffic optimization	Eco-driving	Dynamic last mile delivery	Cooperative traffic signal control	Speed management	Predictive smart parking	Mobile payment	Mobile ticketing
Economic impacts	Growth	4	0	1	1	1	4	1	4	1	0	2	1	0	0
	Economic competitiveness	4	0	1	1	1	2	1	5	1	0	0	1	0	0
	Economic welfare	4	0	1	2	1	2	1	5	1	1	2	1	0	0
	Investment	4	4	3	1	1	1	3	4	1	1	3	1	0	0
	Market share	5	5	3	3	3	4	3	4	2	1	3	4	4	2
	Other factors, specify	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Overall economic impact	**4**	**4 and 5**	**1 and 3**	**1**	**1**	**2 and 4**	**1 and 3**	**4**	**1**	**1**	**2 and 3**	**1**	**4**	**2**
Social impacts	Cohesion	0	2	0	4	2	1	2	1	0	0	0	0	0	2
	Health	4	0	1	1	1	1	1	1	0	1	2	1	0	2
	Employment	3	1	1	1	1	1	1	1	1	0	0	1	0	0
	Quality of life	3	2	0	4	1	4	3	2	1	1	4	3	1	2
	Service level	4	2	3	2	1	4	3	3	1	1	4	4	4	2
	Greenhouse gas emissions	4	0	1	1	2	1	1	4	0	1	2	3	0	2
	Overall social impact	**3 and 4**	**2**	**1**	**1**	**1**	**1**	**1 and 3**	**1**	**1**	**1**	**2 and 4**	**1 and 3**	**1 and 4**	**2**
Policy impacts	More fluid	0	1	1	2	1	1	1	1	1	1	0	1	0	1
	Greener	4	4	1	1	1	1	1	2	2	1	3	1	0	1
	Smarter	4	2	2	4	4	4	1	2	1	1	3	3	0	2
	Safer	0	0	0	2	2	2	1	3	1	1	4	0	0	0
	More accessible	1	1	1	2	1	2	1	1	1	1	0	2	0	2
	Overall policy impact	**4**	**1**	**1**	**2**	**1**	**1/2**	**1**	**1/2**	**1**	**1**	**3**	**1/2**	**0**	**1/2**
Technological impacts	Innovation	4	2	3	4	2	4	2	4	0	1	0	3	0	2
	Technological breakthrough	4	4	3	3	3	3	3	4	0	0	3	1	0	0
	Research competitiveness	5	3	1	3	3	3	3	3	0	1	0	1	0	3
	Standards agreements	4	5	3	4/0	0	4	4	4	0	0	3	4	4	2
	Industrial leadership	4	4	3	3	3	4	3	3	0	1	3	3	4	3
	Technological leadership	5	4	3	1	3	3	3	4	0	1	3	4	4	3
	Integration	4	4	3	4	0	4	3	4	1	1	3	4	0	2
	Knowledge transfer	4	3	3	2	0	1	3	4	0	0	0	3	0	0
	Infrastructure development	4	4	3	2	0	1	2	4	1	1	3	1	0	0
	Mobility of personnel	3	2	0	2	3	4	3	4	0	1	1	2	0	2
	Overall technological impact	**4**	**4**	**3**	**2 and 3 and 4**	**3**	**4**	**3**	**4**	**1**	**1**	**3**	**1 and 4**	**4**	**2 and 3**
	Overall impact		1/2	1	1/2	1	1/2	1	1/2	1	1	2	1/2	1	1/2
		3		3	3	3		3				3	3		3
		4	4/5		4		4		4			4	4	4	

Legend:	
0 = no impact	
1 = minor impact, within the city limit	City / Regions
2 = potential impact, reaching regional level	
3 = potential impact, reaching national level	States
4 = potential impact, reaching EU level	EU
5 = potential impact, reaching global level	

Table 17: Summary of bundle assessments

The results also show that impacts of various bundles, and even services, vary a lot. Most significant impacts, perhaps not surprisingly, are those that are linked with technological changes. It should be noted that different services require varying amounts of investments, which can affect the speed of providing the service to the market in real life.

Social impacts appear to be the least significant; in particular to see cohesion improvements as a result of the bundles is difficult in most cases. The exception to this rule are social media applications, which can be considered to bring new users to the traditional social media as a result of the benefits that they will gain from combining social media applications with their transport system information needs.

One of the activities carried out was to look at the various bundles from both a sustainability and an efficiency point of view. From the comparison we can see that electric mobility services score the highest overall impact, with booking and payment having the lowest overall impact. In terms of the policy advice arising from the assessment, supporting urban logistics services could have the biggest impact on efficiency of the system.

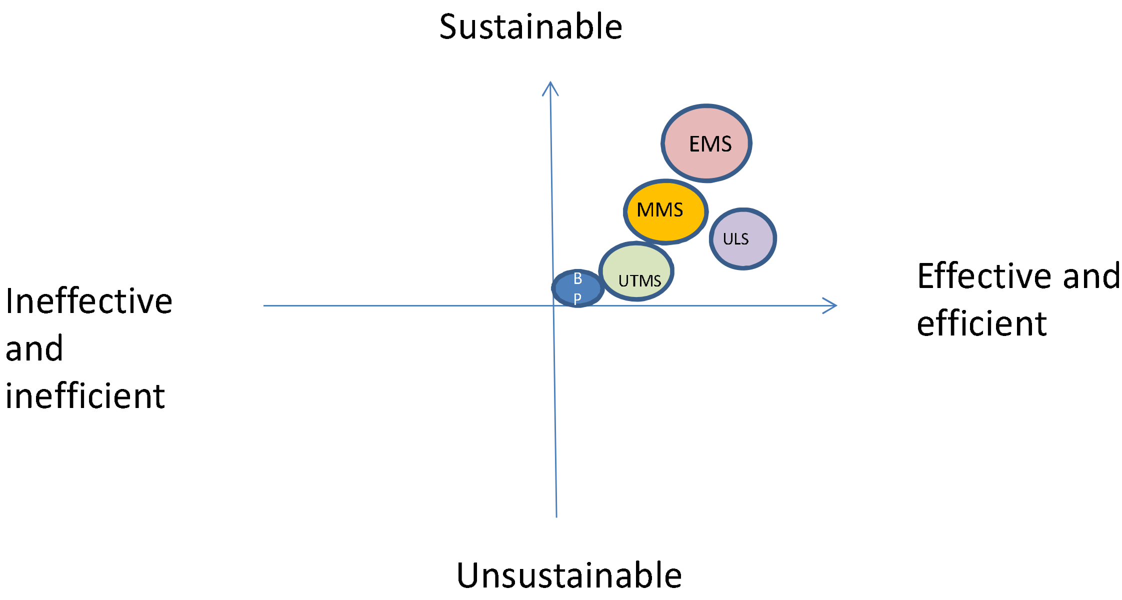

Figure 19: Comparison of bundles

The legend in the picture refers to:

- EMS = Electric mobility services
- MMS = Multimodal mobility services
- ULS = Urban logistics services
- UTMS = Urban traffic management services
- BP = Booking and payment

To summarize, there are clear differences between the bundles assessed, which can be further elaborated by carrying out more detailed analyses and by contrasting the transport sector bundles with other sectors (assuming, for instance, the need to compare investments and their impacts in transport and health sectors).

5.4 **Conclusions**

The final choice of what technologies should be invested in and brought forward in the implementation agenda naturally depends on the impacts aspired. Different governments, including cities as well may wish to take forward initiatives that suit their interest. Therein lies a potential caveat, if certain services and bundles require penetration rates that make them economically feasible for private companies to invest in. This is in particular the case with information systems that require huge data bases, high-speed processing and user support services. Companies are not willing to take risks in terms of investing into these unless they can be convinced of sufficient coverage and user potential. Uncoordinated activities, in the absence of standards or policies, will lead to extrapolation of current situation where individual initiatives mushroom and will not generate broader utilization of innovations beyond the local context where implemented.

One of the assumptions that we have stated behind the spread of information system services is the reasonable roaming charges, which are slowly emerging in the European scene. However, in order for users to be able to access services that require constant data transfer the fees need to be further reduced. In the case there is no low cost data transfer available, many applications will not be utilized across national boundaries. This will reduce their attractiveness to users, investors and potential partners such as advertising companies.

It is envisaged that there will be more cultural and language barriers in the actual implementation than it would seem from the offset. The use of applications across borders makes it necessary to consider this, particularly regarding tourism. Some services also do not consider special groups, such as elderly people, who demand tailor-made applications that are easy to use and correspond to their technical knowledge and competence.

Some services also include security issues related to user data handling and passing information between users. The rules of the game need to be clear enough so that users can trust that their rights are not violated by the service data collection. Integrity and security must have a high priority in designing the practical service provision. It should be also noted that in terms of the technological impacts not all the services generate a major impact as they will be based on existing technologies and applications. In these cases it is recommendable to see how the service will improve the other categories, as these services and bundles are low cost options compared to those where major investments are required.

6 Recommendations

6.1 Introduction

The study is intended to support the decision making process concerning required policy actions in the area of ICT research, development and innovation by providing an assessment of the most important systems and models able to resolve some of the challenges related to smart, efficient, safe and clean mobility by

- Elaborating a set of recommendations for the enhancement of ICT take-up in cities, these include innovation topics and technologies, integration aspects in cities and single applications and service packages;
- Defining best practices in cities which support these developments and the related information exchange between cities and stakeholders involved.

The aim of this chapter is to identify gaps between current ICT infrastructure and areas were future needs derived in the study can be used to form strong positions at EU and worldwide level. On this basis the elaborated recommendations for strategic research and implications concerning innovation strategy and policy provide a path for combining the best ways of ICT technology deployment in European cities. Figure 1 shows an overview of the workflow, indicating how the recommendations were developed. The analysis is divided into two parts, an overall analysis of the impacts from a European perspective and the detailed impact analysis of different service bundles. The detailed impact analysis describes the economic, social, policy and technological impacts and derived recommendations of the services shown in Table 11.

6.2 Analysis and Recommendations

This chapter focuses on the impact of current and future ICT technologies on the evolution of Smart Cities. Based on the assessment conducted in chapter 5 a matrix was produced (see Table 17) which forms the basis for analyzing impacts and to elaborate recommendations. Based on the coverage and usability of the discussed ICT technologies all impacts can be regional (on city level), national (on country level) or European.

6.2.1 *Overall analysis of the impacts from a European perspective*

6.2.1.1 *Economic Impacts*

The analysis shows that the economic impact of almost all services is on a city level. Only four services show economic impacts on a European level:

- Intelligent charging for electric mobility services, where an investment to a robust European wide and user friendly system needs to be ensured.
- Electric mobility support services like payment facilities need to be provided as well on a European scale in a standardized way to manage bookings across borders.

- For personal multimodal traveler information services the interest is also on a European perspective. And this kind of services is expected to have one of the biggest economic impacts of all services evaluated in this study.
- Eco-driving services also show the highest economic impact on European level, as the assumption data use as well as the availability is expected to be Europe-wide.

But even if the impacts of the other services are on city or regional level, European harmonization will pave the way for deployment serving our citizens best. While all evaluated ICT services have exactly the above described impacts on economic growth, competitiveness, welfare and investments, one exception is with the impact on market share. Here a higher impact is expected on European level, since many services will be provided on a European level. Here companies will provide integrated pan-European services covering more than only one service bundle which will help to overcome the fear of the deployment of isolated proprietary systems. This goes hand in hand with European expectations on the competitiveness of the European transport system.

6.2.1.2 *Social impacts*

Social impacts are assessed with respect to employment, quality of life and service. As social impacts are addressing the single individual, most of the impacts are, similar to the economic impacts, on city and regional level. This counts especially for cohesion, health, greenhouse gas emissions and employment. Out of the evaluated categories only quality of life and service level have a bigger European dimension.

Increased opportunities of some services can lead to improvements of quality of life at European level. Here awareness building is crucial which is likely to support a more social use of the road infrastructure (e.g. social traffic, eco-driving) and additionally boost the use of public transport (e.g. personal travel companion).

Also the category service level has a notable European dimension as several services will only be accepted by the citizens by having them deployed in a harmonized and seamless way. It is expected that here interoperable deployment will lead to sustainable improvements in travel across Europe, e.g. it will lead to a reduction in accidents and better predictable travel times.

6.2.1.3 *Policy Impacts*

The policy impacts are assessed in the light of recommendations formulated by the European Commission. Reviewed challenges have been discussed in the Green Paper on urban mobility that the European Commission adopted in September 2007. They need to be addressed, if the European Union’s overall strategy to fight climate change, achieve objectives for energy efficiency and renewable energies, and strengthen social and economic cohesion is to succeed. In total five categories (challenges) have been identified, where four out of them primarily have an impact on regional and city level only: more fluid transport, greener transport, safer transport and better access. All these categories need local measures and have even a more local impact.

The only category where a bigger European impact is expected is with introducing smarter services. Here smarter urban transport can help to increase efficiency. Smart charging, intelligent public transport ticketing and better traveler information may be part of the solution. It is expected that e.g. commercial ITS services using a crowdsourcing methodology can help in solving various problems as a community of drivers will be able to warn other drivers about traffic holdups in a particular area. By implementing such services using standard interfaces a minimum degree of interoperability of ITS applications in towns and cities can be assured and a potential EU level impact can be achieved.

By looking at the services it seems that especially for intelligent charging systems a European dimension can be seen. This especially as this kind of service will have a high impact on health, particularly through a reduction in emissions. These factors will improve the quality of life even at the EU level.

6.2.1.4 *Technological Impacts*

The analysis shows that the technological impacts are mainly on national and EU level. A European impact can be expected in the categories innovation, integration and standard agreements which should create the basis for harmonized and seamless services. The impacts of other categories like technological breakthrough, industrial leadership and knowledge transfer are likely to remain on national level. The same applies for research competitiveness except for intelligent charging where the impact can reach a global level. The infrastructure development for some services like e.g. cooperative traffic signal control or predictive smart parking will remain on city and regional level, while for other services like e.g. intelligent charging or speed management it is expected to reach EU level to ensure interoperability and wide usage. In case of European coverage, several services have the potential to result in technological leadership at European level if providing systems/services independent of location or language, resulting in greater interoperability.
The technological impact of services like dynamic last mile delivery or cooperative traffic signal control is likely to remain on city and regional level, while dynamic car sharing and speed management will reach national level. Other services like intelligent charging, electric mobility support services and eco-driving are expected to have technological impacts on European or even global level.

The analysis revealed the high importance of certain technologies in the future. Almost all mobility related services rely on wireless communications of different kinds, here the key drivers are wireless broadband and flat rate pricing (including international roaming). Location technologies are the heart of most of the services as well as provided data and information. Multiple techniques and their hybrids are needed to cover most of the situations and providing required accuracy and precision. One of the key end-user service trends is geo-socializing.
Sensors are the key ingredients of smart environment and pervasive computing for monitoring and controlling environment as well as allowing ubiquitous interaction with physical infrastructure. The envisioned Internet of Things and Machine to Machine related technologies will also emerge to manage the increasing complexity of sensor networks. Near Field Communications (NFC) will be a central technology in mobile payment. In addition to payment, this technology opens many new opportunities also in other service areas.
Massive data management will be in the heart of many traffic services that are based on the holistic view on the urban traffic. In addition, real-time requirements and spatial computing puts pressure on computing power. Cloud computing is the enabling layer for service provision by managing complexity and scalability on behalf of the service providers, and for end-user services as their applications and personal data are accessible ubiquitously.

User needs are often combinations of the features currently provided by several different services (e.g. parking in a foreign city), here the integration of the services and providing them as multi-provider service wholes is a key issue in end-user satisfaction. Innovative, contextual and safe user interaction is a paramount feature of the services in the traffic context. For that reason, transferring desktop user interaction paradigm to the mobile contexts (e.g., to in-car use) is not usually appropriate. New solutions utilizing, e.g., multimodal and natural user interfaces must be developed.
Perhaps one of the greatest challenges in the innovative traffic and mobility related services exploiting users' whereabouts and behavioral patterns. Technologies and solutions can be (and must be) fool proof and still used in a way that users do not get suspicious. In addition, means to build trust among the service users are needed.

6.2.2 ***The detailed impact of different service bundles***

6.2.2.1 *Bundle: Electric mobility services*

Intelligent charging

The analysis shows that for intelligent charging a European dimension can be seen.

Economic impacts
Intelligent charging is one of few services which show an economic impact on European level. The future competitiveness of the transport system could be secured by investing into a robust and user friendly charging system resulting in a shift towards alternative energy sources. With regard to the rising fuel prices, the growth impacts can be significant if the system is advanced in Europe. The service will increase energy self-sufficiency and decrease the dependency from a European point of view, if the source of energy is from a European origin (and increasingly from renewables) resulting in an increased economic welfare. Major investments in the public and private sector are required to meet the needs of the new system (e.g. filling stations etc.). It can be expected that new companies will emerge within Europe to provide the service needed. The influence on the market share could be significant if the expertise can be gained prior to the rest of the world and can be utilized to gain global advantage in provision of services in other regions as well. Intelligent charging has significant economic potential, which can be fulfilled by early and large-scale introduction in the European markets. Therefore also actions from car manufacturers are required as the penetration rate of vehicles must reach a critical mass to provide incentives for investments required, in particular from private sector.

Social impacts
The service will lead to a reduction of CO_2 as well as other emissions from transport, which can have significant positive health impact depending on the penetration rate of the electric vehicles. It is likely that the employment is also positively affected since the industry will create new jobs (partially offset some of the jobs at present in traditional service industry) and as new distribution channels are needed as well as infrastructure construction there is likely to emerge more employment opportunities. An improvement of the level of service can be expected due to new designed charging services to more easily recharge the vehicle. This can lead to sustainable improvements in travel within Europe. These positive health and employment effects as well as the enhanced service level are likely to create positive impact on quality of life. The shift to alternative fuels from fossil fuels will reduce emissions, which will further improve the quality of life and leads to health

impacts as well. The service will have a high impact on service level and health, particularly through a reduction in emissions on a European level. These factors will improve the quality of life even at the EU level.

Policy impacts

The service can lead to a reduction of transport emissions and result in a greener transport system on a European scale if a broad coverage is achieved. Intelligent charging systems can enable a smart and integrated environment and potentially reach an impact on EU level. The level of accessibility, for electric vehicle owners and user, can be improved by providing services like e.g. bi-directional charging in residential buildings as well as making this mobility solution more affordable.

Technological impacts

The service has a big technological impact and potential for global coverage, depending on initial investments required, penetration and the coverage of the service provision. The availability of alternative energy in the transport sector will be significantly improved by the technology and further has the potential to create major innovations in the service delivery methods. The combination of environmental friendliness and intelligence will open new markets and service providers, but the provision of the service in the new way across Europe will lead to a breakthrough that challenges the traditional energy provision in the sector. Moreover, it has the potential to enhance the global competitiveness of European transport and energy sector. The system must have an agreed European standard on mode of charging and the way it is provided (equipment etc.) that the service can be available across national borders. The market will attract several companies that operate across national borders and provide services through established brands. In context of the future role of vehicle manufacturers in the global competition, those which participate in a European wide scheme can become global frontrunners, but at present these companies do not necessarily originate from Europe. Various technologies from different fields (smart systems, energy, infrastructure etc.) need to be integrated in the holistic system and significant knowledge transfer is necessary to define the European wide service model. An early market introduction can result in global technological leadership. To reach the required level of service significant developments in infrastructure are foreseen.

Effects of trends in ICT technology

Intelligent charging needs the integration of mobility services with energy services. Developments of Smart City technologies like Smart Grids or Internet of Things and basic ICT technologies like cloud computing will have a positive influence on these services. Potential security and privacy issues have to be addressed as well.

Recommendations

- Intensify and push the stakeholder dialogue (on EU level) for
    - the integration of technologies from various fields (smart systems, energy, infrastructure etc.) which need to be integrated to a holistic system
    - the definition of a European wide service model
    - investments which need to be done (short-term action)
- Agreement on a minimum requirement definition for standards on operating the system (short/mid-term action)
- Set up of a European standard on mode of charging and the way it is provided (equipment etc.) (short/mid-term action)
- Future research activities should focus on the following ICT technology trends: Smart Grids, Internet of Things, security and privacy

Electric mobility support services

The analysis shows that the impact for electric mobility support services has mainly impact on city/regions and European level.

<u>Economic Impacts</u>
The main economic impacts are on the European level and beyond as the utilization of the services is based on (most likely) existing frameworks used for payment of similar services.

<u>Social Impacts</u>
The management of payment and booking systems as well as maintenance of parking facilities with charging opportunities is likely to create new employment but mainly in the limited to city context where service provision will take place. Service level improvements are mainly experienced within city and regional traffic where volumes of traffic are greatest and improvements can improve the penetration rate of electric vehicles rapidly.

<u>Policy Impacts</u>
For electric vehicle users both route guidance and navigation systems integrating the location of charging points can lead to an optimization of the path to be followed. Consequently, there could be a positively impact on the fluidity level of road traffic. Integrated electronic payment of all mobility services including electro-mobility ones have a positive impact at city and regional level in terms of making the urban transport more intelligent through ICT applications. In addition to the payment the information of electro-mobility services in the city integrated within the information on mobility services and energy related information like price, availability and level of battery charging can definitely improve the accessibility of such mobility services at city level.

<u>Technological Impacts</u>
The service has wide-ranging technological impacts that reach the European level impacts. These support services help to improve the use of new services and essential in achieving the goals of greater penetration. European level integration is needed to ensure the coverage and operability of the service. Both payment and booking systems will need to operate at the European level to offer service users in order to make the service attractive to users and to become broadly utilized. Payment standards related to service must be global, whether they are based on credit cards, mobile phones or Smart Cards.

<u>Effects of trends in ICT technology</u>
In context of electric mobility support services, developments and improvements of technologies regarding wireless communication, location technologies and Internet of Things will play an essential role. Technologies improving booking and payment systems (like e.g. NFC), travel information and navigation, energy management or the user interaction will ease the integration of electric mobility services with the urban transport system.

<u>Recommendations</u>
- Development and support of regional electro mobility demonstrations to verify the management of payment and booking systems as well as maintenance of parking facilities – (cooperation of regional road administrations, cities and service providers is necessary) to be done in Public Private Partnership (PPP) to gain best- and good-practice examples and lessons learned for the further deployment (mid-term action)

- Starting of a consolidation process for the definition of global standards for payment related to Electric mobility support services - international standardization bodies (mid-term action)
- Support of the deployment of electro mobility support services based on the lesson learned from the demonstrations (long-term action)
- Future research activities should focus on the following ICT technology trends: wireless technologies, location technologies, Internet of Things, energy managment

Urban electric freight

Analyzing the potential for urban electric freight main impacts have to be expected on city level. Cities will experience the potential of the utilization of electric vehicles for freight transport. When considering the technological impact dimension urban electric freight is likely to have a broader impact, as the service will be provided on national level.

Economic impacts
The analysis of the economic impacts (like growth, competitiveness and economic welfare) of urban electric freight shows that the main impact will remain on city level. So the companies within the city limits are able to improve their local operations with the service, they can provide more green service concepts and gain broader acceptance in partnerships. A generation of new business for the local companies through this service will prepare the ground for potential welfare gains.
The investments in the required technology need sufficient resources, so it is likely that major companies, operating at national or European level will invest in the technology installation. As a consequence the provision of the service is expected as national level business and the gains in market share are experienced by these companies that invest in the technology, most likely either overall service providers or most advanced logistics companies. From the current point of view the system will be developed by one company for several clients that can utilize the fleet charging systems or some logistics companies that reserve the technology mainly for their own use or rent out services to other companies also adopting same business concept.

Social impacts
Some minor effects on health within cities (because of the reduction of emissions and the less traffic noise) are expected, as well as the creation of some new jobs, for management and maintenance of the service. An improvement on service level is most likely (because of the provision of the service in the cities) concerning the system for the management of the service and the vehicle fleet and the service, so logistics companies as well as their clients will benefit from the service (on a national level).

Policy impacts
On city level the provision of the service can improve the efficiency of the urban freight, by optimized routing and numbers of daily deliveries, booking of loading and unloading areas, and is expected to have an impact on the smartness of the city or region. The use of the electric cars for the urban freight has definitely a positive environmental impact.

Technological impacts
From a technological point of view the main impacts are expected on a national level as innovation is linked to the overall infrastructure provision for electric vehicles, which is likely to emerge in national context, where the operations can be administrated in a new

way (as well as the service -> see economic impacts). Standards on operating the system need to be enforced a national level (minimum requirement). The needs of the logistics sector and of the electric vehicle technologies need to be integrated to provide a robust system. This requires an intensive dialogue on national level in generating a service model and in order to make the use of the electric vehicle more common. New infrastructure will be required to provide the charging to vehicles in new locations.

Effects of trends in ICT technology
Developments in technologies like Smart Grids and location technologies as well as battery technologies will have a positive influence on urban electric freight, as well as enhancements of related services like e.g. booking and payment, navigation services or energy management.

Recommendations
Whereas the economic impacts will remain on city level the service need to be provided on national level. So the target groups for the recommendations are relevant stakeholders from public authorities on national level, as well as relevant cities and regions.

- Stakeholder dialogue (on national level) for integration of technological and logistics needs with stakeholders from technological side, public authorities (national, regional, city), logistics sector
- Agreement on a minimum requirement definition for standards on operating the system on national level to avoid isolated systems
    - Stakeholder dialogue: public authorities (national, regional, city), technology providers, service providers
    - The standard definition should go hand in hand with European definitions
- Agreement on access regulations for city areas, incl. permissions for electric freight vehicles to support the use of electric freight vehicles (cities – agreed on regional and national level) (short-term/mid-term action)
- Pilot regions for the implementation of the service step by step (short-term/mid-term action)
- Support for the development of technologies and emerging services on European level
- Future research activities should focus on the following ICT technology trends: Smart Grids, location technologies, battery technologies, energy managment

6.2.2.2 *Bundle: Multimodal mobility services*

Social traffic

Economic impact
The economic impacts are likely to remain on city and regional level. The improved efficiency of the transport system will have a small impact on growth and competitiveness. The reduction of travel time will lead to a positive effect, for society and individuals, on welfare. No significant investments are required except from data storage facilities and there might be the necessity for additional data management services. It is expected that there will be one service provider within a country, probably a European wide provider will emerging in case of a profitable business model.

Social impact
The simplicity to use new mobile applications in combination with existing technologies can lead to significant impacts on social cohesion on European level. The new opportunity

created by social media and easier communication methods will result in improvements of quality of life in a European dimension. More as well as better information regarding potential threats and obstacles can potentially reduce accidents. The service level can be enhanced mainly on city and regional level, if the service is available across Europe the benefit can increase when people move from one city to another.

Policy impact

The possibility for drivers to give feedback about traffic and road conditions to the cloud to be interpreted, verify and distributed to other equipped drivers can lead to a better use of the road network and a more fluid traffic at local and regional level. Enhanced navigation services providing better routing information will result in less congestion and consequently increase the air quality at local and regional level. The use of crowdsourcing at ITS services can help to make it smarter and solve challenging issues since drivers can warn others about traffic holdups in certain areas. To ensure a potential European wide impact, it is necessary to use standardized interfaces to assure a minimum degree of interoperability. Social traffic services can provide rapid and appropriate information and so increase the safety level at city and regional level. By using this crowd sourced traffic data in traffic information services it can be ensured that a wide number of people can be reached to achieve more accessibility. It is important to promote the adoption and deployment of such services to all European urbanized areas, to achieve an impact on sustainable mobility on a European scale.

Technological impact

The analysis shows that main technological impacts will be on city/regional and national level. The service will increase the European connectivity, innovation will be mainly within the new content. The challenge will be the large scale service provision, which will require data integration, including cloud services and user interface infrastructure development. This technological breakthrough might serve as integrator between social media and traditional traffic information applications. It requires an agreement at EU level of the principals of data usage, including the reliability and responsibility of data quality. It can be expected that the service provision will be done by one company in a country, which will have national leadership. When the service is provided by a global company, the application could reach world-wide usage. The service will be implemented at city/regional level but using EU know-how. In case of a European-wide coverage, applications will have European integration impacts through the social media coverage of the area. Social traffic information with better data availability will lead to a benefit for commuting traffic and could also support public transport and light traffic.

Effects of trends in ICT technology

In context of the service, developments in cloud computing, location technologies will play an essential role. Crowd sourcing can be further developed e.g. user interactions could be based on audio only to report observations which could result in enhanced navigation services. Security and privacy is also a big topic, since in social services people willingly provide information for others' good, but want to control their own privacy.

Recommendations

- Start agreement process on standardized interfaces between authorities, service providers, cities and other stakeholders to assure a minimum degree of interoperability (mid-term action)
- Agreement at EU level of the principals of data usage, including the reliability and responsibility of data quality (short-term action)

- Develop and support for setting up pilot regions to test services that give the driver the possibility to give feedback about traffic and road conditions to the cloud to be interpreted, verify and distributed to other equipped drivers (mid-term action)
- Further research on the possibilities/technologies for crowdsourcing at ITS services on European level (mid-term action)
- Future research activities should focus on the following ICT technology trends: location technologies, multimodal interaction, security and privacy, cloud computing

Dynamic car sharing

Economic impact

The economic impact is likely to remain on city and regional level. Volume of cars on roads and congestions can be influenced, depending on the penetration rate. The resulting time savings will improve productivity and generate growth effects. The impacts on competiveness and welfare are expected to remain small. Investments besides standard city level technologies are not expected. It is likely that a single company develops an application which can be used within a country and in case of success probably a European wide provider will emerge. If vehicle manufacturers want to become mobility providers they need to team up and invest heavily.

Social impact

The analysis shows that also the social impacts are expected to remain on city and regional level. The creation of cohesion impacts can be achieved by linking supply and demand of commuting travelers. The impacts can also be observed within a regional commuting pattern in form of longer route commuters using car sharing or less congestion in the inner city resulting in a positive environmental impact due to reduced emissions. Improvements in quality of life, limited to city and regional level, can be expected due to a reduction of traffic within the city and an availability of a better connectivity through car sharing. New dynamic car sharing services can increase the city attractiveness to commuters as well as other users within a city.

Policy impact

The service can have a positive impact in urban and possibly regional dimension. The fluidity of the traffic can be enhanced by providing the possibility of spontaneous trips in combination with a trip planning system which optimizes travel distances and pick-up points and provides re-routing options. The reduction of cars in the city and dynamic re-routing according to traffic situation can lead to a better urban environment. ICT based solutions are essential in such a demand-driven vehicle-sharing arrangement to guarantee the screening of all parties involved and technical solutions bringing different parties together, managing rental bookings and collecting payments. The level of perceived safety and security will increase by having all users registered, but the service needs to let users set several options like maximum waiting time, pick up locations, but also regarding the other passengers (e.g. only women or men) to increase their comfort. The flexibility to offer or request a ride just a few minutes before the actual departure leads to more accessibility.

Technological impact

The technology impact is expected to be in national context. The innovation in technology will have a regional level making commuting and leisure traffic operate more smoothly. The service will be most commonly used within national boundaries, at city level the service will show a new solution for transport system users. The competition on the service provision might be within national boundaries, it is likely that only one service provider will remain to cover a national market. This national level service provider is expected to provide leadership at the national level. The service has an impact on mobility of personnel at national level, giving people without a car the opportunity to travel according to their travel needs. The further development of location technologies can positively influence the service, but security and privacy issues have to be addressed and solved.

Effects of trends in ICT technology
Similar to social traffic, dynamic car sharing will benefit from developments in cloud computing, location technologies and wireless communications. The use interactions are challenging and change all the time, therefore improvements of the multimodal interaction will result in additional enhancements. The legal aspects ensuring security and privacy for the user need to be clarified.

Recommendations

- Stakeholder dialogue on national level involving all relevant stakeholders (e.g. public authorities, service provider, specific user interest group), but also including European level stakeholders (e.g. CIVITAS) for the definition of legal recommendations for ensuring security and privacy for the users, further national legal regulations, minimum requirements (mid-term action)
- Set up of pilot regions for dynamic carsharing (jointly with bike-sharing) to increase the user acceptance and gain awareness for such systems and develop good practice examples (including payment and booking systems) (mid-term action)
- Promotion of sharing-schemes (car and bike), increase awareness and user acceptance on national level, by service providers in cooperation with cities and regions (short-term action)
- Further research or actions on European level based on the results from projects like e.g. SUNSET[8] (short/mid-term action)
- Future research activities should focus on the following ICT technology trends: cloud computing, location technologies and wireless communications, multimodal user interaction, security and privacy

Personal travel companion

Economic impact
The economic impact of personal travel companion is one of the biggest among all services and can be seen in a European dimension. Growth impacts within a city are based on time savings from better information and travel opportunities. The competitiveness of a city which adopts this service can increase as well as the welfare due to more efficient traffic data. Major investments will be required in terms of data management systems, therefore it’s likely that a single national service provider will emerge.

Social impact
On the one hand, at city level a significant cohesion impact can be expected but mainly related to travel planning. Moreover, a positive effect on health is likely due to more opportunities to utilize public transport efficiently as well as light traffic, but also limited to

[8] http://www.sunset-project.eu

city level. On the other hand, at European level the quality of life is likely to increase, due to better information availability on the transport system which will enhance the use of public transport and reduce congestion, and the service level will increase and create opportunities to assist visitors and tourists to improve the service provision.

Policy impact

The policy impact remains mainly on city and regional level. The provision of information on the progress of the trip and re-planning (e.g. in case of unpredictable events or change of travelers plan) results in an improvement of the urban management center and consequently reduced congestion. The service will increase the attractiveness of public transport which leads to a greener transport system. Based on future internet technologies the service can give a multi-modal travel assistance to users. In case of travelers helping them to plan and adjust in real time multi-modal door to door journey, vehicle drivers to e.g. easily book and find parking places and transport operators to provide them with complete information which is necessary to initiate demand-driven transportation. The safety can be improved due to real-time information and the resulting possibility to prevent users from unsafe situations. Personal travel companion eases the way to plan a trip by taking personal preferences, city rules, current requirements and constraints into consideration which leads to a better accessibility to the transport service.

Technological impact

The analysis shows that the technological impact is mainly on national and European level. Personal traffic companion has the potential to become European wide available, can have innovation potential that spreads across all countries where the service is provided and to those who can use it when visiting these countries. The innovation is to offer passengers better real-time travel information in a user-friendly way at European level. No major technology advancement is necessary except for the data management. Each application developed for a city and country will have certain specifics, therefore it is likely that the solution providers will compete at national level. There are several possibilities for a national or a multi-national service provider, but also that a system is developed in a multi-national context and then licensed to national service providers, which would improve and ease the interoperability and standard processes. System integration is needed at EU level to ensure a broad user base, which can be supported by the use of multiple media for data provision, user friendly pricing and interface solutions (including roaming costs). The service has major impacts on utilization of existing technologies. Penetration rate is the key to successful coverage and usability.

Effects of trends in ICT technology

New developments in the areas of processors, memory technologies, cloud computing and the Internet of Things are expected to have an impact on quality of the service since the complex system consists of a number of systems, data sources, and massive real-time data. Since the services are mobile and heavily contextual, enhancements of wireless communication and location technologies will lead to an improvement of the service. Also use situation are challenging and change all the time, in this context augmented reality and multimodal interactions play an essential role. Applications and services continuously track user's location and activity and also payment is included, security and privacy has to be ensured.

Recommendations

- Stakeholder dialogue on European level including authorities, service providers, users and other stakeholders to define requirements and needs (accessibility for all

users (e.g. handicapped people)) as well as data provision and quality (short-term action)
- Agreement on standards for data format, quality on national level (mid-term action)
- Design a European standard for the interface to ensure interoperability (mid-term action)
- Future research activities should focus on the following ICT technology trends: location technologies, processors, wireless communication, Internet of Things, Multimodal interaction, augmented reality, battery technologies, security and privacy

Incentive-based traffic optimization

Economic impact

Traffic optimization can lead to significant time savings for travelers, but limited to city level. The same applies to economic competitiveness, the service will only affect the immediate surroundings. Users of the system can take advantage of reduction in travel times and improved travel data, but impact of the service on economic welfare takes place within geographical context. The impact on investments and market share is expected to be at national level since massive data storage and management is required. It is likely that a national service provider will emerge and manage the system within national boundaries.

Social impact

The service has a social impact at city and national level. The improvement of the availability of travel information will result in improved cohesion at national level by providing enhanced access to the transport system for the users. A positive effect on health might be experienced, in case people utilize more public transport due to the reduction of emissions as well as efficiency gains but only on city level. Easier trip planning due to better travel information will improve the quality of life on national level. The service enables a travel planning which copes better with short-term changes and therefore enhances the service level due to the availability of multimodal travel information.

Policy impact

The policy impacts are limited to city and regional level. Incentive policies can promote an optimized traffic by rewarding travelers who change their behavior (according to the policies) and so can make the transport system more fluid. The creation of a set of rules that users have to fulfill and rewards they can earn (e.g. take the bike instead of the car to receive a coupon from a bike shop etc.) can lead to a greener urban environment. Services like personal mobility sensing can identify and localize any unsafe situations and so can increase the level of safety. Sharing their personal mobility patterns on a certain platform simplifies the integration with other functionalities the platform can offer and so increase the quality of access.

Technological impact

The technological impact is mainly on national level. The integration of various data sources, incentive schemes and maintenance of a massive database are necessary at national level. Existing sub-services have to be integrated into the operational service offered, this requires the coordination of best available methods at the implementation. Standards for data security and user privacy have to set and access rights have to be defined for various stakeholders without compromising the privacy of the individual user.

Significant investments are required for management of the data and creating a well-functioning user interface. It is likely that one national service provider will emerge and offer the service within a country. National providers may also expand across Europe to smaller member states for which it is not suitable to establish the service own their own. Therefore the knowledge transfer will take place mainly on national level, in some cases also technology solution will be transferred from one country to another. Sensors from vehicles have to provide route information on-time, in this context investments with the city and regional area are necessary. The service will result in an improvement of travel patterns and the integration of use of public transport to day-to-day movement in a more efficient way.

Effects of trends in ICT technology
Enhancements of basic ICT like processors and Smart City technologies like Internet of Things and cloud computing will improve the system to deal better with the number of systems, data sources and massive real-time data. The development of wireless communication and location technologies will be a relevant area of interest since the services are mobile and heavily contextual. In terms of location and activity tracking of users, improved battery technologies can increase the quality and availability of the service, but security and privacy issues have to be taken into account.

Recommendations

- National stakeholder dialogue (e.g. public authorities, service providers, specific user interest group) on
  - the creation of a set of rules and rewarding systems
  - the integration of existing sub-services into the operational service
  - common data collection and formatting (short-term action)
- Agreement on standards on data security and privacy on national level (mid-term action)
- Definition of minimum requirement standards regarding data access and use by service providers and authorities at European level (mid-term action)
- Policy incentives, f.i. in form of challenges which are defined as a set of rules and user have to fulfill them in order to earn rewards (in this regard virtual mobility could be of high relevance), on national level to influence the travelers' behavior. (short-term action)
- Future research activities should focus on the following ICT technology trends: Processors, Internet of Things, cloud computing, wireless communication, location technologies, battery technologies, security and privacy

6.2.2.3 *Bundle: Urban logistics services*

Eco-driving

Eco-driving has a European wide dimension. But the analysis shows different impact levels in the various categories, especially the social and policy impacts, where cities and regions are the main impact levels.

Economic impacts
Eco-driving services show in the analysis the highest economic impact on European level, as the assumption data use as well as the availability is expected to be Europe-wide.

Through the optimization of routes and the interrelated fuel savings eco-driving services for freight vehicles can lead to greater efficiency of the whole logistics chains and can therefore generate growth within the regions where the service is available.
The greening of transport and the expected fuel reduction can create a competitive advantage on European level (compared to the rest of the world) and will be significant in terms of required energy imports. With a European coverage of the service the welfare gains will be globally significant.
Massive investments in data storage and processing in order to integrate the various types of data (incl. user profiles and preferences) for the service should be expected.
Based on the need for basic data sets it can be expected, that only a few companies will dominate the market and the service will be a single service for the whole European market. Critical factors for the impact of the service will be a sufficient number of cities and users of the service.

Social impacts
Social impacts of eco-driving can be expected as well as on city/regional level, as well as on European level. Reduction of fuel and energy will lead to reduced greenhouse gas emissions and can have a positive impact on health issues in high densely populated areas like cities. Maintenance and user assistance require staff, which will have an impact on the employment on regional level. The service will improve quality of life through reduction of travel costs, reduction of emissions and travel time savings, which can have a European dimension (with sufficient deployment of the service).

Policy Impacts
The analysis shows the major policy impacts on city/regional level. Especially on urban level, the eco-driving for the logistics sector will increase the fluidity of the traffic. The enhancement of ITS applications in these areas by using cooperative vehicle-infrastructure systems to collect and exchange energy-relevant data between vehicles and roadside can improve the preview of the traffic situation ahead in order to determine the most economical route or way of driving. This will lead to better performance and reduction of the energy consumption and is expected to have a positive impact on safety (on city or regional level, in case of safety also on national level).

Technological Impacts
A high impact on innovation is expected, when combining the different features of the service (incl. mobility, data storage and processing, real-time travel support, monitoring of the conditions of the vehicle,…). This multi-functional data management service is a major challenge for service integrators. One major challenge on European level is the agreement on availability of data for the system and the way of data collection and provision of data for the service providers in order to ensure a maximum coverage of the system across national borders.
The service will require smarter infrastructure across Europe that can take into consideration the requirements of the information collection and provision envisaged in the service delivery. Maybe some components will require alteration of the existing physical infrastructure to be fitted.

Effects of trends in ICT technology
Because of the technological challenges that this service is facing, trends in basic ICT, like processors, but also memory technologies and cloud computing, are expected to have an impact on the quality and availability of the service. The development of Smart City technologies like wireless communications and locations technologies, as well as internet of

the things, will be a relevant area of interest, especially when regarding collection and provision of high qualitative basic data sets for the service. Development of new technologies for user interaction, for multimodal interaction as well as for augmented reality will create additional value for the user and are likely to improve the service quality from the user's point of view (assisted by innovative ULs and possibly Head-up Displays on the wind-screen (multimodal interaction, augmented reality) while driving, etc.).

<u>Recommendations</u>
As eco-driving has a major impact on European level, one of the critical challenges is the deployment in a sufficient number of cities/regions/nations and sufficient number of users of the service (across borders), so that the impact will be noticeable.

- Consolidation process on European level on data availability, collection and provision of data
  - Stakeholder process (public authorities, representatives of the freight and logistics sectors, service providers, standardization bodies, vehicle manufacturers,…) (short/mid-term action)
- Development and support of pilot regions (mid-term action)
- Support of deployment of eco-driving systems in European cities/regions based on the lessons learned of the pilot regions (for setting up the service incl. the infrastructure)
- As the integration needs compatibility between different national level systems the technology development has to be done on European level, also large scale demonstrations of new technologies (mid-/long-term action)
- Future research activities should focus on the following ICT technology trends: Processors, wireless communication, locations technologies, Internet of Things

Dynamic last mile delivery

The analysis shows that dynamic last mile delivery has main impact on a city/regional level. Positive impacts on European scale can be significant, by adoption and deployment of these services to all European urbanized areas.
As we can see in densely populated areas the need for logistical optimization is highly important. The last mile delivery is one of the trickiest parts of the logistics chain, going hand in hand with the fact of increasing numbers of last-mile direct deliveries from a courier to the consignee (f.i. due to increasing eCommerce), which lead to more deliveries and new challenges for optimization in delivery.

<u>Economic impact</u>
On the economic side this service can improve the logistics and efficiency within a city or a region and can therefore create some growth impacts, as the deliveries become more rapid. The availability of the service can improve small business operations and will have therefore a positive impact on the competitiveness of these local companies that take advantage of the service. Companies, benefitting from the service can generate welfare gains, but as last mile delivery has a relatively marginal impact on the whole logistics chains, the impacts remain mostly on city level. For the service itself no investments can be expected. Last mile deliveries are provided mainly by specialized companies, either as part of a broader logistics chain or as a separate niche market and can be provided by multiple entities within a country. So the expected market share is likely to appear on the city or regional level. The service will improve the service level experienced by the end users of logistics services, so major economic impacts can't be expected.

Social impacts

The availability of a dynamic last mile delivery service allows a greater flexibility of customers in receiving deliveries and therefore will improve the quality of life within cities or regions, where the service is provided. To the same extend the service level will improve considerably and make delivery business smoother and more customer friendly.

Policy impacts

The dynamic optimization of the goods transport will have positive impact on the city traffic fluidity. The optimization of the flows of goods can have positive environmental impact, especially within urban areas. This can be achieved by applying trip planning systems and fleet monitoring. Advanced fleet management systems connected with onboard units gather a set of information that can also be valuable to enhance safety on the urban road network. The customer of the logistics service (the consignee) will have better access to the service regarding quality, efficiency and availability.

Technological impacts

The technological integration of information (locations of service users, deliveries, fleet management and route planning, traffic information, etc.) on a city level is needed to create an impact of this service.
In addition some developments in infrastructure may be required (related to satellite based monitoring of vehicles). The service itself will not require extensive technological advancements but will utilize existing technologies.

Effects of trends in ICT technology

The emerging of technologies in the ICT sector (in particular processors and cloud computing) can lead to improvement of the service. Especially the development of Smart City technologies, like wireless communications and locations technologies will have an impact on dynamic last-mile delivery in order to increase the quality and availability of this service. Internet of the things can lead to new dimensions within the service of last-mile delivery.

Recommendations

- Adoption of the service by a major number of European cities, as the service is expected to create economic impact on a city level, but will also improve the quality of life of the inhabitants of these cities and regions (long-term action)
  Therefore different steps are necessary:
  - Building awareness of the impact of the service at political level in cities, regions and networks of cities (short-term action)
  - Commitment of cities for demonstration and deployment of the service (med-term action)
  - Integration of the data (e.g. locations of service users, deliveries, fleet management and route planning, traffic information) on city level (mid/long-term action).
    Pilots/demonstration projects can be adequate for this task.
  - Support for the pilots/demonstration projects by national or regional funding institutions.
    - The cooperation between service providers and the city/region is obligatory (there might be the case that cities across borders are involved, then several tasks have to be done at European level) (mid-term action)

    - One of the main tasks of the pilots is the integration of different types of information (like locations of service users, deliveries, fleet management and route planning, traffic information)
    - Investments in infrastructure, if necessary
- Commitment for support of projects for test and demonstration of new technologies within real life conditions (mid/long-term) (city level)
- Future research activities should focus on the following ICT technology trends: processors, wireless communication, location technologies, Internet of Things, security and privacy

6.2.2.4 *Bundle: Urban Traffic Management Services*

Cooperative traffic signal control

The analysis shows that the cooperative traffic signal control service has only an impact on city level.

<u>Economic Impacts</u>
Any changes in driver behavior have a direct and a positive indirect effect upon energy efficiency. Significant changes in energy efficiency and environmental friendliness of transport due to the individualization of cooperative traffic signal control are expected. Deployments of cooperative traffic signal control have a high potential to significantly contributing towards decarbonisation of transport especially in European cities. It is expected that a well-functioning cooperative traffic signal control service from a city can easily be adapted for another city in Europe except large cities where commuters have no emotional roots and where fiscal instruments (city tolls) and prohibition will play a significant role already in the years to come.

<u>Social Impacts</u>
Due to the optimization of the traffic flow the people in cities will find driving more pleasant and enjoyable. During off-peaks hours this new service can improve driving when green lights can be made more user-friendly according to vehicles on the roads.

<u>Policy Impacts</u>
The introduction of cooperative traffic signal control will certainly decrease the traffic congestion in European cities. These systems can optimize traffic flows system and so the reduced total delay time of the urban network. In addition to the flows optimization the air quality of the urban environment will be improved as well as the relative safety of an intersection in a city.

<u>Technological Impacts</u>
European cities coping efficiently with challenging road traffic bottlenecks under a low-carbon context will have a significant impact onto European logistics providers and industrial manufacturing and their local employment. The service can be designed and implemented locally, even through the utilization of the local small and medium enterprise sector to provide the required technologies. Furthermore, additional developments need to be addressed to ensure that vehicles are able to communicate with Road Side Units (RSUs) using Dedicated Short Range Communication (DSRC).

Effects of trends in ICT technology

Improvements in the areas of processors, cloud computing, Internet of Things and location technologies are expected to have an impact on the service since it is a real-time data intensive system that continuously calculates optimal traffic signal patterns according to the data coming from sensors and vehicles. In context of security and privacy, the systems controlling traffic infrastructure must be tamper resistant.

Recommendations

- Further developments to ensure that vehicles are able to communicate with Road Side Units (RSUs) using Dedicated Short Range Communication (DSRC) (short-term action)
- Large scale field test to test and ensure robust and reliable services (mid-term action)
- Rolling-out of cooperative traffic signal control in cities involving users throughout the demonstration life time (mid-term action)
- Future research activities should focus on the following ICT technology trends: wireless communication, Internet of Things

Speed management

The analysis shows that the impact for speed management has a different level (City/regions, national or European) for each impact category.

Economic Impacts

There is the need to have investments to provide the signaling system, which will boost the development of durable and low costs variable speed signs required to replace the current signs. Most likely companies emerge as service providers at the national level providing the necessary integrated and centralized system. There can be EU level and multinational service providers as well but since speed management will be controlled by relevant national authorities the main dialogue will take place at the national level.

Social Impacts

The service will improve quality of life on European level as the speed management becomes more linked to actual conditions and less static as it is the present situation. People will also have better chance to adjust their driving and to take necessary precautions against changing driving conditions. In addition to the quality of life the service level of speed management will improve significantly and can lead to reduction in accidents and more predictable travel times. These new features will benefit in particular frequent travelers but will also provide comfort to those who are less frequent traveler or not familiar with local roads and their conditions.
The impacts concerning health result from better control of speed on roads, resulting in less accidents and injuries, which will affect in particular the commuting travel in the city and regional context. Due to the facts that speed management can also optimize the travel speed to avoid queues and congestion in the context of regions.

Policy Impacts

The speed management service can positively impact the state of transport system fluidity reaching a regional level of effects by taking into account the actual current circumstances, such as traffic situation. The optimization of travel speed will also positively impact the level of local emissions not only because of the decrease in traffic congestion, but also through the influence speed management can have on drivers behavior and, consequently, on fuel consumption decrease. Within the aim of making urban transport more accessible for all, also the increase in safety perceived by public transport users should be taken into account especially on city level.

Technological Impacts

To upgrade the service to national level management there is the requirement to develop low cost signs that will replace the existing ones and where the transfer of signal works in all conditions, when a change to existing speed limit shown is required. In addition there is the need on national level to agree on standards between the road administrator and the service provider, to ensure that the management of system meets the requirements of the authorities. National level service providers are likely to generate the leadership that is required to produce integrated systems. These service providers can also provide the similar service to other countries and provide more broad solutions.

Effects of trends in ICT technology

Improvements in locations technologies are expected to enhance the service quality, since it is based on the location and speed of the vehicle. Dynamic speed limit data and updates are transferred wirelessly, therefore improvements in the area of wireless networks will be relevant as well. New developments in the area of multimodal interaction which allow the driver to receive and use e.g. audio and haptic feedback will create additional value for the user and is likely to improve the service quality from the user's point of view.

Recommendations

- Agree on national standards between road administrator and service providers, to ensure that the management of system meets the requirements of the authorities – national road administrations, service providers and standardization bodies (mid-term action)
- Support the deployment of speed management systems in European cities (mid-term action)
- Agree on European standards for speed management – international standardization bodies (long-term action)
- Future research activities should focus on the following ICT technology trends: location technologies

Predictive smart parking

The analysis shows that the impact for predictive smart parking has a different level (city/regions, national or European) for each impact category.

Economic Impacts

The predictive smart parking will lead to less time spent in search for parking spaces and therefore you have a gain in productive time. Additional impact is the increased revenue of the cities from parking fees. In terms of the competitiveness, the savings in time and the related increase in productivity are considered minor. Technologies required will not provide massive investments in physical infrastructure, with the exception of technologies such as cameras and sensors. These do not require substantial investments and most likely are based on utilization of existing technologies.

Social Impacts

The impact on health will be of local nature, mainly resulting from better air quality due to less emissions resulting from reduced search time for parking. The application can improve the quality of life as people spend less time in search of parking space and find the system less stressful than situation before. These impacts can be considered on national level, as travelling from one city to another the availability of dynamic and predictive parking will improve moving around in other cities as well.

Policy Impacts

Well in advance, up-to-date and everywhere information about parking space availability will positively impact the fluidity level of road traffic. The drivers, in fact, will be informed in good time on the current occupancy levels of parking lots and car parks, allowing them to plan their route accordingly and reach their destination in the shortest time possible. By reducing the length of time a vehicle circulated in a car park, gas emissions and noise levels will be reduced and so requirements on better air quality and noise abatement can be met.

Technological Impacts

Only when considered to change the existing services available in cities for parking can the application be considered to have a technological advancement at the city level. Internet of Things, real-time allocation of parking spots is a challenge, which can be solved through private areas, but public areas (road sides) remain difficult to address. Better information on parking can result in changes in commuter habits, which can be an inverse impact in terms of increasing the share of trips done by private vehicles. The innovation lies in the potential to bring the existing technologies together into an integrated service that can benefit commuter and leisure traffic, including tourism, provided that the user interface is designed to work in non-local equipment and platform as well. The potential to have an agreement on the interoperability of various city level applications at the European level to improve tourism and other usage can lead to standards, with regard to functions of the applications.

Effects of trends in ICT technology

Due to the amount of different data sources and massive real-time data, enhancements in the area of processors, memory technologies, Internet of Things and cloud computing will have a positive impact on the quality of the service. Due to the nature of the service, the use situation are changing and challenging, therefore new developments in multimodal interactions and augmented reality will be areas of interests as well. Since this is also a mobile and heavily contextual service, wireless communication and location technologies will play an essential role. The service exploits locations of the drivers, where also payment is included, therefore it security and privacy has to be ensured.

Recommendations

- Announce a study for predictive smart parking to bring the existing technologies together (short-term action)
- Set up and develop an integrated service to gain advantage of the innovation potential (mid-term action)
- Future research activities should focus on the following ICT technology trends: wireless communication, location technologies, Internet of Things

6.2.2.5 *Bundle: Booking and Payment*

Mobile payment

The analysis shows that mobile payment has only an effect on a limited number of impacts in the various categories and mainly on European level.

Economic impacts
Since the service will only lead to minor changes of the current process and in principal aids the current systems in administrating the payment of various services, no impacts on growth and competiveness are expected. Economic impacts are limited and linked to the service provider's role in the European markets. The impact on market share is expected on European level, since this service will - in all likelihood - be provided at European level by one or more companies as is the situation at present with other similar services offered by financial institutions.

Social impacts
The service can lead to improvements of quality of life of service users due to the availability of improved payment services which enhance their everyday activities but limited to city level. Service users will experience an improvement of the service level of their day-to-day travel on throughout European, since the user will benefit everywhere where the service is available. The social interaction itself will not be affected by the payment service.

Policy impacts
Mobile payment services do not have any impacts from the policy point of view.

Technological impacts
Since the service is based on existing technologies, the technological impact is mainly linked to the service provision in form of a new application of existing payment technologies. An agreement regarding payments and data transfer is needed on EU level concerning the format of data and privacy of users of the service. The service will most likely be offered by EU level (or even global) service providers to reach a sufficient geographical coverage and client base. Also the payment management technologies will exist at EU level to ensure the broad-based use. Although, the service is based on existing technologies new developments in the fields of wireless communication, cloud computing and the Internet of Things can lead to further improvements of the service.

Effects of trends in ICT technology
In context of mobile payment, mobile phones with NFC as means of payment are likely to have an impact on the quality and availability of the service. New developments in wireless networks and Internet of Things are relevant areas which could create additional value for the user and lead to improvements of the service. Since this service deals with money transactions, security and privacy has to be ensured.

Recommendations
- Agreement at EU level regarding privacy of users for mobile payment services (short-term action)
- Setting up a consolidation process for the definition of a European standard for format of data of mobile payment transactions – by European standardization

bodies, cities, authorities, service providers and other stakeholders (mid-term action)
- Support of deployment of mobile payment (integration is important) within further big European cities based on lesson learned from the demonstrations, within a cooperation between service providers and the city/region (mid-term action)
- Future research activities should focus on the following ICT technology trends: Internet of Things, security and privacy

Mobile ticketing

Economic impacts
Economic impacts of mobile ticketing are quite limited and linked to the market share. The service is utilized fully within city and their surroundings, most likely by a single service provider. It aims to increase the use of public transport by increasing the efficiency with a new alternative in payment of public transport services.

Social impacts
The social impacts are mainly concentrated on the geographical utilization of the service, which is supporting in particular city and regional travel. An improved ticketing system will enhance the use of public transport, where in particular commuters and public transport users will benefit from the service. The health situation can be positively affected by boosting the use of public transport, this is likely to increase people's use of light traffic (foot, bicycle). The availability of a more flexible payment system will increase the quality of life for service users and lead to an increase of the attractiveness of public transport. Furthermore, an improvement of the service level can be expected in city, the regional commuting traffic and their immediate surroundings. A regional reduction of greenhouse gas emissions can be expected depending on the volume of passengers shifting from use of private vehicle.

Policy impacts
The fluidity of the traffic within a city can be increased by reduced times at bus stops due to faster boarding of people. A mobile ticketing system has the potential to change the citizens' behavior towards the more environmental friendly public transport and achieve less intensive use of private vehicles. The use of just one ticket supports the integration of different transport modes in metropolitan area and will have a regional effect on accessibility of public transport. The use of ICT system such as RFID and NFC can help to increase the efficiency leading to a smarter service. Mobile ticketing can lead towards a more sustainable urban transport system, therefore by promoting the adoption and the deployment to all European urbanized areas, the positive impacts at European scale on the sustainable mobility can be noteworthy.

Technological impacts
The service is based on existing technologies, integrating the payment and ticketing system in a new way. It is likely that the service will be provided by a national service provider, which has already experience in a similar field. Standards for the integration of the payments system within the ticketing systems are needed, but this only in the local context. Similar systems in different cities are likely to be managed by a national level entity. Technical solutions, which will be used in various cities and regions within a country, are generated by the companies which operate these systems. The technological impact is

limited to city and regional level. The beneficiaries are frequent users and service providers which can offer their service to interested operations within a region.

Effects of trends in ICT technology
Similar to mobile payment, trends in wireless networks and the Internet of Things are expected to have an impact on the quality and availability of the service. It is likely that mobile phones with NFC will be used as means of ticketing. Ticket transactions have to be secure and privacy of the user's has to be guaranteed. New developments in the areas of location technologies will support further ticketless solutions.

Recommendations

- Intensify and push a stakeholder dialogue (on national level), with all relevant stakeholder (e.g. service providers, cities, public authority, data provider), for the integration of the payment system within the ticketing system (short-term action)
- Agreement on a minimum requirement definition for standards on operating the system (short-term action)
- Support for setting up pilot regions for mobile ticketing (short/mid-term action)
- Promotion of mobile ticketing to increase awareness and user acceptance on national level, by service providers in cooperation with cities and regions (short-term action) (short-term action)
- Future research activities should focus on the following ICT technology trends: Internet of Things, security and privacy

6.3 **Conclusions**

The analysis of the historical patterns and influencing factors in future mobility trends in urban areas showed three main challenges: urban sprawl, population ageing and higher motorization rates have to be taken into account. The classification with a sample of 44 European cities according to the level of criticality of mobility patterns based on five main indicators (population density, car ownership, car density, availability of public transport and modal shares) showed that large cities, consistently with the analysis of historical trends, are in a critical position in terms of sustainability of mobility patterns. Several cities already developed Sustainable Urban Mobility Plans (SUMPs) to ensure a sustainable mobility in the future. Various ITS applications were assigned to three of the pillars of the sustainable urban mobility (more fluid, safer and more accessible) and put in relationships to the main challenges on future mobility trends indicating their potential area of impact.

The questionnaire carried out within the review of state-of-the-art of advanced ICT based mobility services in urban areas provided an overview about the currently developed ICT infrastructure and applications in various cities, but also visualized current gaps. The survey revealed that there are important obstacles to the establishment of a comprehensive overview of ITS applications across cities in Europe. The diversity of services and of entities responsible for implementation and management makes it difficult to obtain a comprehensive overview which does not exist as such in many cities. Responsibilities for ITS services are scattered among various local actors such as the traffic management department of the city, the transport authority and the public transport operators. In addition, a significant number of mobility services in the city are provided by private operators. Moreover, the survey showed that the most common ITS applications are related to management of the signalized network. The analysis of the legal and regulatory framework included the topics procurement, intellectual property, liability and privacy. It showed that several issues have to be addressed like who is liable if the wrong information is given or potential invasion of privacy have to be addressed and showing future needs. ITS deployment challenges are mainly in organizational and financial areas than technical.

The analysis of ICT technology trends (basic ICT, energy, user interaction etc.) resulted in a list of champion technologies which will be of high relevance in the future and should therefore be considered in future strategic research and innovation agendas:

- Wireless networks
- Mobile devices
- Location technologies
- Near Field Communications (NFC)
- Sensors
- Massive data management
- Cloud computing
- Innovative, contextual and safe user interaction
- Privacy and security solutions

The service impact assessment of all considered services in respect to their economic, social, political and technological impacts showed that impacts of various bundles, and even services, vary a lot. Most significant impacts, perhaps not surprisingly, are those that are linked with technological changes. It should be noted that different services require varying amounts of investments, which can affect the speed of providing the service to the market in real life. Social impacts appear to be the least significant; in particular it is difficult to see cohesion improvements as a result of the bundles in most cases. The exception to this rule are social media applications, which can be considered to bring new users to the traditional social media as a result of the benefits that they will gain from combining social media applications with their transport system information needs. The comparison of the various bundles from both a sustainability and an efficiency point of view shows that electric mobility services score the highest overall impact, with booking and payment having the lowest overall impact. In terms of the policy advice arising from the assessment, supporting urban logistics services could have the biggest impact on the system's efficiency.

The developed recommendations show the need of each service to be developed/deployed (further) by pointing out important steps which have to be taken as well as relevant stakeholders who need to be involved for supporting a fast take-up. Overall it can be concluded that from the technological point of view most technologies necessary for a specific service are already available to a certain extend/in a certain quality. Most of the issues appear rather in the organizational and financial than in the technical area. For almost all services standards for data for format and the respective quality need to be established, therefore the involvement of all relevant stakeholders is necessary. Several processes can and need to be handled on city level, while others need the involvement of stakeholders on EU level. The integration of services of different kinds and sectors needs to be achieved to create a greater gain in all sectors by integrating services into the Smart City, which will also provide opportunities for the greater integration of the individual in its urban environment.

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ANNEX A - Examples of ITS services in cities

DHL dynamic route planning in Berlin

DHL has developed Intelligent pick-up and delivery vehicles using dynamic route planning to reduce time and distance driven. This system is deployed in Berlin where Berlin, Siemens, who operates Berlin traffic management center, and DHL are using intelligent traffic management systems as part of a dynamic route planning. To help achieve this, the partners have established cooperation for the collection and use of traffic management data from the traffic control center for the benefits of Smart trucks guidance system for the DHL fleet of vehicles operating in the city.

ICT services supporting electromobility in Barcelona

www.livebarcelona.cat

LIVE Barcelona (Logistics for the Implementation of the Electric Vehicle) is an open public-private platform promoting the use of electric vehicles in the city. It is promoted by the Government of Catalonia, Barcelona City Council, the Spanish Government, SEAT, ENDESA and SIEMENS.

As well as providing information for the general public "Punt LIVE" is also issuing the electric vehicle user's card required for using the municipal network of recharging points. Through the Website and social networks such as Facebook or Twitter it provides practical information for users such as the map of the more than 240 charging stations, including some fast charging stations. Electric vehicle services accessible through LIVE include e-scooters and e-bikes as well as electric cars.

Barcelona Network Operation Center is where all questions are centralized - monitoring of the infrastructure and interoperability between individual control centers of the different suppliers. The NOC communicates with 76 ground-level charging points installed by the City Council and Endesa and their status is displayed on the website, together with information on charging stations from other operators.

The Hague Smartline

The Hague Smartline is an example for an application dedicated for a specific route. It is implemented for the route connecting the Central Railway station and the Dutch Parliament used by a large number of and local inhabitants. This local council's initiative aims to increase the accessibility of the city. The SmartLine guides visually impaired people along this track by providing “push” and “pull” information consisting of navigation information, information regarding the buildings and information regarding the public transport platforms alongside. The information presented on audio channel via a smartphone or PDA.

ANNEX B – Questionnaire on the deployment of ICT mobility related services in cities across Europe

The objectives of this questionnaire are:

- to contribute to establish a picture of the level of deployment of ICT mobility related services in cities across Europe;
- to identify the relevant legal framework and the potential barriers for the deployment of ICT mobility related services (ITS);
- to provide input on some possible paths forward towards Smart cities for other activities carried out in this study.

The questionnaire has been pre-filled on the base of the information available and identified in the literature and through research. It is aimed at supporting an interview to establish a picture of ICT mobility related services in your city.

I. Description of ITS applications

Can you indicate whether each of these ITS applications is implemented in your city and describe briefly this application?

Policy objective	ITS APPLICATIONS		
More fluid	Urban Traffic Control		
	PT Priority		
	Fleet Tracking		
	Loading Bay Monitoring		
	Taxi Monitoring		
	Parking Guidance		
	Parking Availability		
	Traffic Guidance		
Safer	PT Video-surveillance		
	Pedestrian Management		
	Incident Management		
	Speed enforcement		
Greener	Access Restrictions	For cars	
		For heavy duty vehicles	
	Park-and-Ride		
	Bike-and-Ride		
	Car Sharing		
	Bike Sharing		
	Car Pooling		
	Freight Delivery Access/Time Slot Monitoring		
	Other Traffic Management Systems		

Policy objective	ITS APPLICATIONS		
	ITS applications for electromobility services		
More accessible	PT Passengers Information on-ground		
	Pre-trip Information by Fixed devices		
	PT Passengers Information on-board		
	Pre-trip Information by mobile devices		
	On-trip Information by VMS		
	On-trip Information by portable devices		
	On-trip Personalised Information		
	Parking Booking		
	PT Ticketing		
	Parking Payments		
	Alternative Services Payments		
	Services for disadvantaged people		
	Enforcement	parking	
		other	

II. Communication technologies

Do you have a fibre optics network used for cameras, signalized junctions, VMS, other (please specify)?

What is the % of the city with Public Wi-Fi coverage?

What is the % of the city with cellular coverage?

What is the % of the city with WiMax coverage?

III. Specific questions

Example for Vienna:

Do you have pre-define strategies for an incident in the Urban area (not on the motorway)?

Do you have pre-define strategies for an incident in the ring road or the near motorway?

Please specify what are the measured used in incidents (i.e., meter the # vehicles with the traffic lights, inform VMS, send SMS to the registered users…)?

Is the P&R option implemented under In-Time/iMove successfully into the journey planner application?

Is the city following the use of the "Green City Streets" application and its results?

IV. ITS deployment challenges, including legal and regulatory issues

1. Please indicate the main barriers to ITS deployment in order of importance (1=most important, 7=least important)
□ Organisational/institutional
□ Technical (interoperability, integration, legacy)
□ Financing
□ Benefits/impact assessment
□ Awareness
□ Legal/regulatory
□ Other (please specify):

2. Is there an institutional arrangement within your city to oversee ITS matters (such as a cross-departmental or an interorganisational committee or strategy focused on ITS)?
□ no
□ yes (please describe) …… …… ………

3. Is vendor lock-in (the practice of being tied to a particular ITS supplier) commonplace in your city (and country)
□ no
□ yes (please explain how this matter is being addressed, if at all) …… …… ………

4. Is the deployment of ITS within your city primarily driven by policy?
□ yes
□ no (please explain the main drivers)
…… …… ………

5. Please describe the main principles of the ITS procurement process within your city, is it adequate for procuring the technologies and services you expect in the conditions (contractual and financial) you are aimaing at ?
…… …… ………

6. Has your city established key performance indicators for transport
□ no
□ yes (please specify the KPIs)
……
……
………

7. How is the performance of ITS-enabled measures assessed with your city?
□ it is not assessed
□ performance assessment is undertaken (please indicate)
……
……
………

8. Are proprietary systems part of the ITS deployed within your city?
□ no
□ yes (please indicate any difficulties you have faced, for instance relating to upgrading or expansion)
……
……
…………

ANNEX C – Examples of emerging services

Table of content

List of Figures and Tables

In the following we describe few examples of emerging traffic related services that contribute to the optimization of the traffic in smart cities. The concept of "emerging" here is a bit problematic as often the services do not emerge from nothing but are results of service evolution. The first generation of certain service is probably simple and often little clumsy version of the service which is then enhanced with new features and optimized to work better in later versions of the service. The selection examples in this section consists of services that do not yet exist as widely used services but mere ideas, descriptions, prototypes and in some cases as experimental local services with small user base.

As writing this, there are only 8 years of near future to look at and in that time range we believe that there will not be big disruptive surprises that would raise from the traditional traffic related industries like car manufacturing or traffic infrastructure solutions. This has its implications on the service examples selected in this document. Consider, e.g., the renewal rate of motorized vehicles in Europe. The size of car fleet in Europe was 2009 roughly 236 million vehicles with average age of 8.2 years, and there were roughly 13 million registrations of new vehicles in the same year [ACEA 2011]. It means that only about 1/20 of the car base is renewed yearly. For that reason we have left out, e.g., the emergence co-operative systems based on the vehicle-to-vehicle communications before 2020 – even if it is under significant research and standardization efforts just now. The same holds for infrastructure, where renewal rate is in many cases even more conservative.

There might be some trends, however, that will have quicker and greater impact to traffic related services than those welling from the traditional traffic related industries. Mobile location-based services (LBS) and social media as well as entertainment and infotainment will bring their ingredients to the soup. Traffic policies increasingly promote public and light transportation instead of building broader streets. Younger generation does not see passenger cars as important as earlier generations. All, these trends will move the emphasis from the road traffic centred thinking to holistic view on mobility and the motivational factors behind that. These trends have also impacted on the selection of the service examples in this section. Multimodality in the mobility, participative social media as a part of people's mobility and support for ecological choices have been intentionally made visible in the service selection.

The service bundles and emerging service examples selected under inspection in this report are presented in the table below.

Electric mobility services
Intelligent charging
Electric mobility support services
Urban electric freight
Multimodal mobility services
Multimodal on-trip services • ***Personal travel companion***
Social traffic services • ***Social traffic information*** • ***Dynamic ride sharing***
New mobility concepts • ***Incentive-based traffic optimization***
Urban logistics services
Eco-driving
Dynamic last mile delivery
Urban traffic management services
Cooperative urban traffic management • ***Cooperative traffic signal control***
Speed management
Dynamic and predictive parking service
Virtual mobility services
Consumer telepresence
Booking and Payment
Mobile payment
Mobile ticketing

Table 18. Selected service bundles and examples of emerging services.

6.4 Electric mobility services

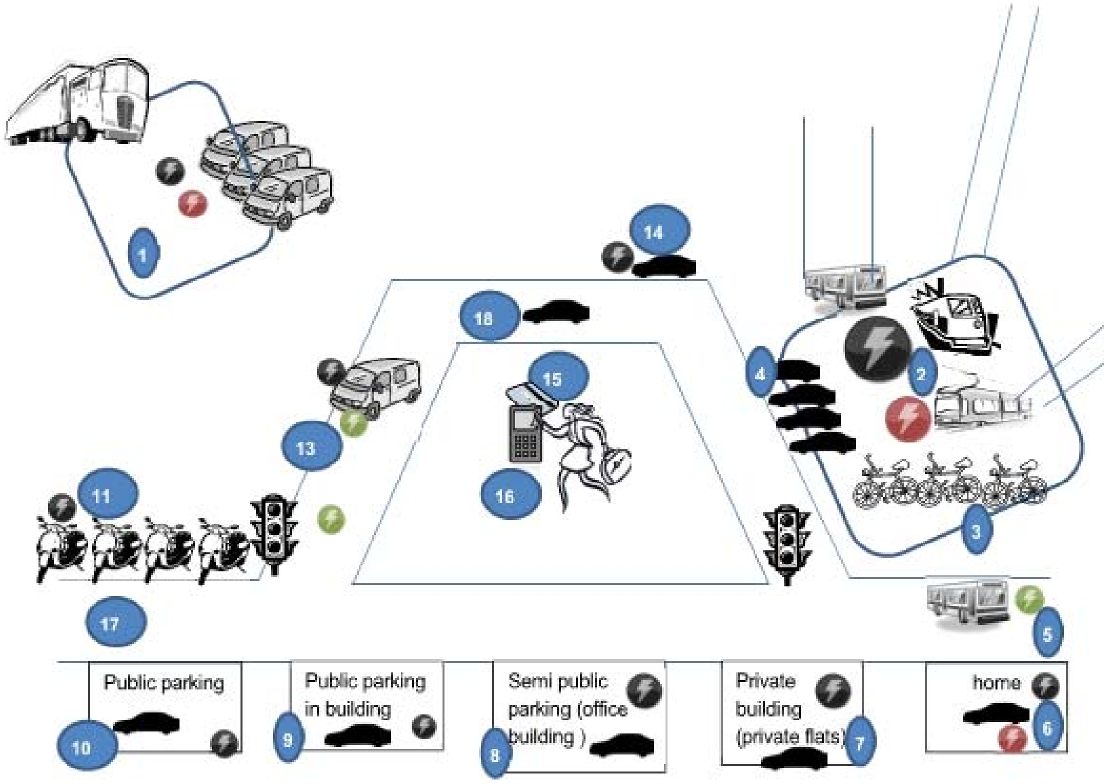

Figure 20. Electric mobility services.

6.4.1 *Intelligent charging*

A. Integration of electromobility services with energy services

5: inductive charging for electric buses at bus stops, ICT for the energy management of the grid and the autonomy of the vehicles to enables safe charging and grid reliability;
6: bi directional charging at home, supported by electronic billing integrated with energy bills and the energy management of the home

7: bi directional charging in residential buildings , supported by electronic billing integrated with energy bills and the energy management of the building

8: (bi?) directional charging in semi public parking such as office buildings, supported by electronic billing integrated with energy bills and the energy management of the building. Electronic booking of the parking spaces, navigation information for occasional / public users.

9: public parkings in building: booking and electronic payment of charging points, energy management integrated with the energy management of the building

10: fast and slow charging points in opened public parkings, ICT for the energy management of the grid and the to enables safe charging and grid reliability;

12: inductive charging at traffic lights

For all cars & PTW: Car2grid communication for eCharging

6.4.2 *Electrcic mobility support services*

B. Integration of electromobility services with the urban transport system

2: Mutimodal hub

- Booking and payment of fast/slow charging points on public parking
- Booking and payment of public or shared vehicles (ebikes, cars, powered two wheelers)
- Energy management of the building integrated with the provision of electricity to the road vehicles and to and from rail vehicles (trains, trams)

3: booking, payment, travel information and navigation information related to the use of public ebikes
4: booking, payment, travel information and navigation information related to the use of electric public/shared cars
11:booking, payment, travel information and navigation information related to the use of electric public/shared powered two wheelers
14: booking and payment of parking and charging on street, related travel and navigation information for EVs. Route guidance and navigation systems integrating the location of charging points, possibly accurate range prediction based on various factors (weather, topology, etc.)
Automatic parking enforcement at charging points
Availability and location of battery swap station, navigation towards battery swaps stations
15: Integrated electronic payment of all mobility services including electromobility services, integrated electronic payment of energy services including electromobility services.
Several paths towards integration:

- Smartcard
- Credit card
- Mobile phone

Several technologies are available, including NFC.
16: information on electromobility services in the city integrated within the information on mobility services, energy related information (price, availability, level of charging of the battery) available on mobile phones/nomadic devices.
Information about the environmental impact of a trip/use of a vehicle, integrating the environmental impact of the fuel production and generation.
Multimodal trip planning including electromobility services.
18: Traffic management and information including EVs & their charateristics (energy efficiency, range, environmental impacts, etc.

6.4.3 *Urban Electric Freight*

Urban freight delivery

- 1: Urban distribution center:
  - Booking of fast/slow charging areas
  - Navigation services
  - Integration of efreight for the purpose of freight consolidation
  - Integration of energy management for the facility with the provision of electricity to the vehicles via the provisions of a charging (slow and fast service), ICT for the energy management of the grid and the to enables safe charging and grid reliability

- 13: Booking of loading and unloading area equipped with charging points, differentiation between fast and slow charging, plug in and inductive charging

- 17 Access control differentiating freight PEV

6.5 Multimodal mobility services

Travellers in the urban areas use various kinds of transportation means and the interplay between these services is not sufficient enough to support ecological and sustainable mobility that optimizes transportation resources and travellers time use. In addition to enhanced trip planning systems based on real-time information, services must address sustainable mobility trends including co-use and sharing of the resources, park & ride solutions, promotion of light traffic (bicycling and walking) and social media utilization in traffic. Notable here is that, none of the mobility related services should work in silos but in an integrated way so that travellers can build optimal combinations of the mobility services and transportation means for their needs and values (e.g., environmental friendliness as a guiding principle). The services in this service bundle emphasize integration of different mobility services, real-time information, and dynamic on-trip support. In addition, we see that future services should tap peoples' willingness to support and optimize their co-travellers' mobility with their own efforts, and thus social traffic solutions are strongly visible in examples.

6.5.1 *Multi-modal on-trip services*

6.5.1.1 *Personal travel companion*

Personal Travel Companion described in [Li+ 2012] is an application that enables pre-trip planning, on-trip planning and support for journey execution. The first part enables the user to plan her trip in advance with the help of the trip planning system that suggests best alternatives for the execution of the journey for the user using one or more mobility modalities. This is what currently available systems already do: provide trip plans based on the static timetables of public transportation. However, there is hardly any service that goes beyond that: guide the traveller on the trip using real time information about the location of the transportation vehicles and the traveller and dynamically alter the trip plan, where required. Add to that automatic ticket purchasing for every leg of the multi-part and multi-modal journey (and cancellation of the purchase if cancelled leg in the trip) and there are more complexity that can be handled today. Personal Travel Companion is defined to handle this all.

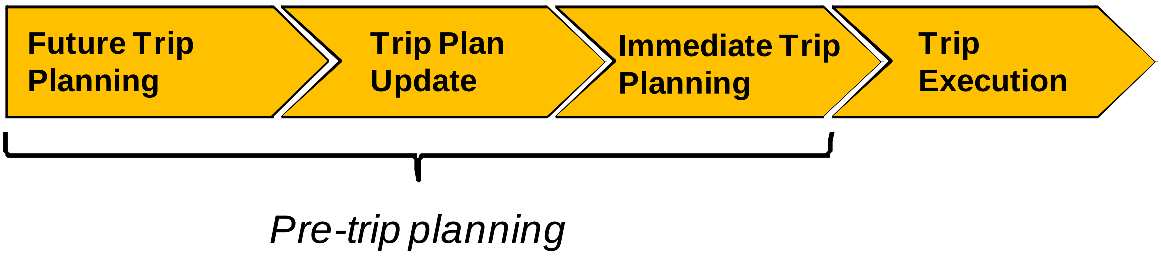

Figure 21. Personal Travel Companion supports traveller in all phases of multi-modal journey (Adapted from [Li+ 2011].

Figure 21 shows the phases of the workflow of a typical travelling scenario that Personal Travel Companion is intended to support. The pre-trip planning part is the preparation phase where, with the help of the Personal Travel Companion and its trip plans suggestions, traveller works out the optimal trip plan for her upcoming journey. Trip planning takes into account the current means of transportation, the traveller's context and preferences, the city rules and the current requirements & constraints. Once the traveller accepts the trip

plan, the required resources are committed to her use involving, e.g., ticket and seat reservations.
The pre-trip planning exists includes two different scenarios:

1. *Future Trip Planning* that is made well in advance in order to early reservation of resources of to get overall indication of the trip duration and required resources. It is based on the static information like timetables and calculated mean travel times. Just before executing a trip, there is a need for *Trip Plan Update* to check for current conditions, availability of previously expected means of transportation and possible optimization.

2. *Immediate Trip Planning*, in turn, is made just before willing to start the trip. It utilizes real-time data about the travelling related resources in addition to static information. In this way, the traveller gets more exact and realistic conception of the current situation and travelling alternatives. This, naturally, requires, e.g., real time spatio-temporal information about transportation fleet, available seats, traffic information, travel time estimates etc.

After pre-trip planning phases Personal Travel Companion continues to support travelling, e.g., by:

- providing information on the progress of the journey,
- guiding the user in the transitions in multi-part trip,
- re-planning the trip because of unanticipated events in transportation or change of traveller's plans, etc.

Finally after trip the traveller may be queried for feedback on his journey in order to enhance the services and give other travellers information that supports them in their trip planning.

Payment Operator back office system
- Provides *secure mobile payment mechanism* for mobile payment and account management services for travellers
- As a financial clearing house it serves transport operators by managing all the payment transactions with *high performance, security and reliability*.

Traveller system
- Uses any terminal connected to Internet with wireless communications (e.g., *LTE, Wi-Fi*) and providing *browser based applications in cloud environment* for trip planning and transportation information acquisition
- Mobile terminal is can also used for *ticketless mobile payment* with *NFC technologies*
- *Positioning* capabilities are utilized to contextualize the service when possible
- *Positioning* is used also to track the traveller in order to monitor the progress of the journey and possible needs to change the trip plan on the fly (*hybrid positioning* needed to complement *satellite navigation*)

Road-Side Units
- Road-side units (e.g., on bus stops) use sensor & WPAN technologies, video/image analysis monitor the passing transportation vehicles to complement GPS navigation, and e.g., the number of people on the bus stop etc. in order to provide information about transport demand for transport service operator

Transport operators

Payment operator

Transport service operator

Internet

TIC / TCC

UMTS / LTE / 3G / WI-FI

Transport service operator back office system
- Transport service operator collects all the **transport operators** under the same service in order to provide holistic multi-modal travel service for a region
- Manages together with transport operators the transportation fleet and optimizes its use utilizing *position and XFCD data* received from vehicles
- Provides trip planning and trip execution services utilizing static and dynamic real-time information
- Tracks traveller positions for dynamic trip planning and execution
- Requires *extremely high performance massive data management, real time data dynamic processing, spatial data processing, privacy solutions, extensive Internet communication capacity (IPv6) and Internet of Things*

Access Control

Park & Ride
- See **Dynamic & Predictive Parking.**

Vehicles
- Vehicles are equipped with *satellite / hybrid positioning* units that are optionally integrated to *OBU and CAN bus*
- *Mobile communication unit* that sends the *vehicle position and XFCD* to transport service operator
- Optionally XFCD is sent to TIC / TCC

Figure 22. Dynamic multi-modal journey application.

6.5.2 *Social traffic services*

Since early Internet visions [Licklider+ 1968] one of the most important characteristics of the computer networks has been their ability to virtualize inter-personal communication and communities. Computer Mediated Communication, Computer Supported Social Networks (CSSN) and Social Media are now flourishing stronger than ever and they are producing a significant portion of the services and content attracting people online.

Advances in the development of cellular networks, smart mobile terminals and mobile application development environments have enabled the emergence of the social network applications also in the mobile phones. Mobile terminal is not only just another terminal device to access social services of Internet but with its context sensing capability it adds a new dimension to the traditional social applications. Social interaction can now be enriched with context information, currently most notably the location. Services bound to locations (using, e.g. GPS) or real world objects (using e.g. NFC) shifts the social applications and services from virtual realm towards real world by providing mixed reality experience with digital content and services bound to real world locations and objects. FourSquare is currently perhaps the most successful mobile location-based social networking (i.e., geo-socializing) application and new innovative services in this area are emerging.

Despite of the great success of social computing in Internet world and its emergence in the mobile environment, it is only emerging in the context of transportation related activities.

In 2010, Oskar Juhlin found the absence of social media one potential reason for poor success of some ITS initiatives:

> *[...] the way IT support for traffic (ITS) has been conceived is influenced by traditional transport planning. This explains why so little attention has been given to support for social interaction. This neglect has consequences for people on the roads and the design of urban quality of life, but it might also be of importance for those struggling to implement ITS in practice. Despite their efforts, ITS has not yet resulted in a shift regarding how traffic is organized. [Juhlin 2010]*

Juhlin also notes that on the commercial sector of ITS services only GM On Star has gained some success while other attempts (e.g. Ford's Wingcast) have flopped.

While ITS roots its evolution in traditional traffic planning, other players are entering to the scene from different traditions, like personal navigation, car manufacturing and Internet services. The scene is currently fragmented and consisting of heterogeneous group of players ranging from some big navigation and map services enriching their services and a bunch of small, experimental application and service developers with small customer base. The use of social media and crowd sourcing in traffic services is certainly emerging but its role is still small and only major application is still based on the floating car data collection from navigation devices and services. In the following, we briefly define some emerging traffic related applications and services, from which two first with little more detail and the rest shortly to enlarge the view to the potential of social media in traffic context.

6.5.2.1 *Social Traffic Information.*

TomTom, Google, Inrix and Waze are examples of companies utilizing their users' input collecting traffic flow and traffic incident data for their navigation related services. In addition, several social applications and services provide information about points of interest, bicycle and walking routes, keep track to the fuel prices in different gas stations etc.

Above we mentioned that user may already use some applications to report their observations in order enhance navigation services. However, this crowd sourcing can be further developed. For example, user interaction could be based on audio only as in the prototype service Road Talk described in [Juhlin 2010]. Road Talk is based on the location-bound voice memos containing drivers' observations on the road network environment. These memos, recorded on the site of observation, are stored in the system that follows the location of its users. These location-bound memos are then proactively played to other users as they approach the site of observation.

Another example of enhancement would be realized by connecting reporting to the observations made by an on-board unit and vehicle sensors. Intelligent on-board system can recognize at least some of the incidents automatically from anomalous measurements (e.g., from strong deceleration and on-board camera image processing) and proactively ask driver to confirm if the incident was the proposed one.

Important part of utilization of the user-originated information is the back office routing of the collected information, not only to the other service users, but also to the authorities, maintenance, researchers etc. Solutions that convey the crowd sourced traffic information automatically and efficiently to right responsible parties, such as authorities in Traffic Information Centres (instead of stored only in service provider's database) would ensure that important traffic information reaches as many people as possible. Users' observations may also significantly speed up and optimize, e.g., the planning and implementation of the improvements with respect to some deficiency in the traffic infrastructure (e.g. dangerous pot hole in the road). Such socially collected data and information could even become commodity that could be provided through open market place similarly to the floating car data (FCD) in the TRACK&TRADE project envisioned [Kelpin+ 2007]. Figure 23 depicts general architecture of a system supporting social traffic information.

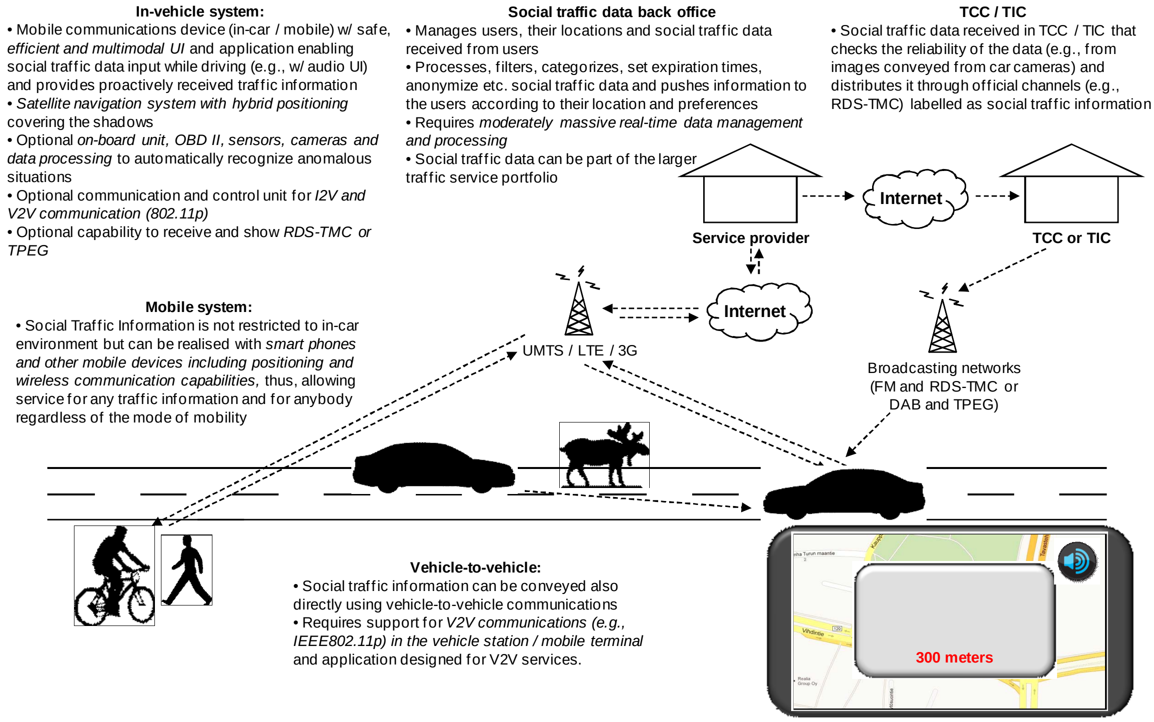

Figure 23. Social Traffic Information

6.5.2.2 *Dynamic ride sharing*

Sharing vehicles in urban areas yields less cars and more efficient resource use. Car clubs and car-pooling (car sharing) are examples of already existing solutions for optimizing urban traffic. Above that, in recent years, peer-to-peer car rental services have emerged in several European countries (see [Wikipedia 2012]) enabling individual car owners to make their cars available for others to rent. Typically this process includes use of brokering company and ICT based solutions, e.g. to protect the car owners as well as the renting customers.

In addition to sharing vehicles also other resources, like parking places, could be shared by providing market places and social applications that enable efficient and safe way for everyone to share or rent some resource in their possession. More innovations in traffic resource sharing are still needed in order to attract more people optimize the overall resource use in mobility related activities using the alternatives based on sharing rather than owning. For example, most of the sharing services require that the sharing transaction is planned, negotiated and committed well in advance. In the following, we describe a service that meets people's ad hoc needs.

Dynamic ride sharing application proposed, e.g., in [Arnould+ 2011] and [Li+ 2012] complements the pre-planned car or ride sharing scenarios with on-the-fly scenario where private drivers already on the way and passengers in the need of ride can agree ride sharing in an ad hoc way. In this scenario [Li+ 2012]:

- A private driver initially provides its destination to the itinerary system of the trip planning service which, in turn, returns with an optimized itinerary (route to destination).

- While driving the driver will get updates and news regarding traffic issues.

- Driver can at any time declare to the itinerary system his acceptance to get common ride proposal from the traveler candidates in the need of ride.
- The system will then add its vehicle to the available sharable vehicle set and the vehicle OBU will start reporting periodically its position until reaching its destination.
- During the trip, common rides (for all or parts off the driver itinerary) with traveler(s) are proposed to the driver with the rating of the proposed traveler(s).
- For each agreed proposal between the driver and the traveler, the application manages all the common ride(s), i.e.: the meeting points, route re-optimization, the check-in and check-out, the in-journey security and the billing.

Figure 24 sketches general architecture for the dynamic car sharing system.

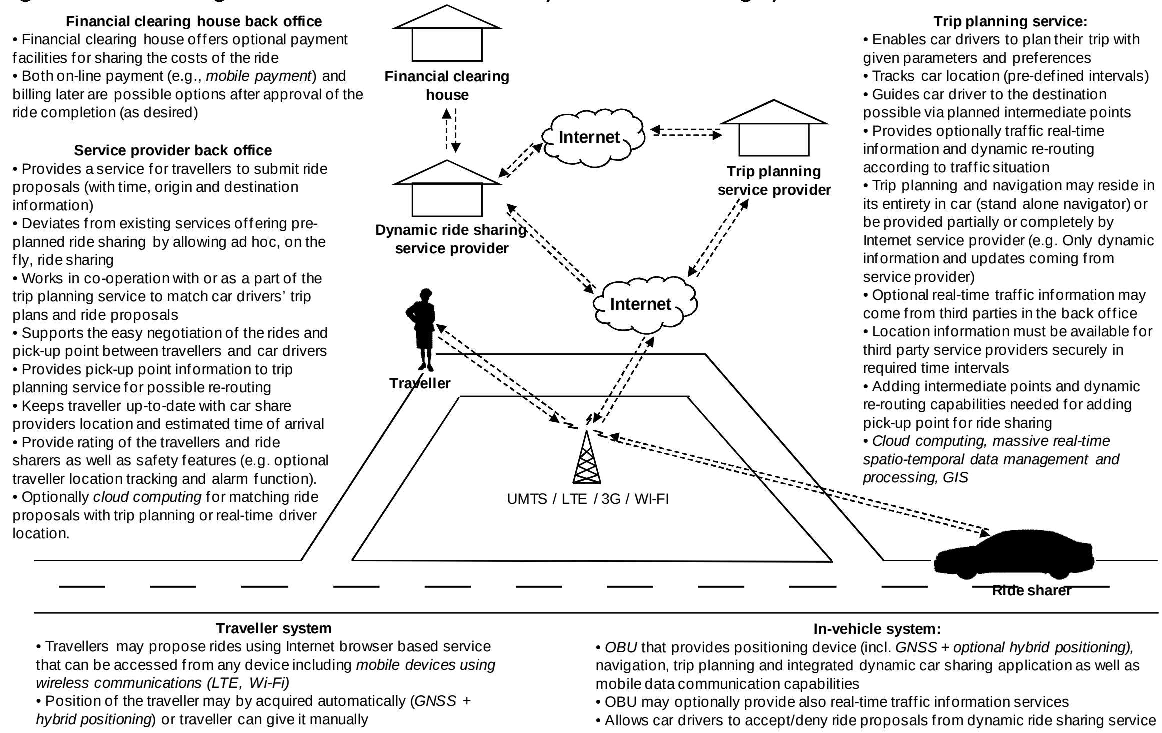

Figure 24. Dynamic car sharing

6.5.2.3 *Situated social interaction in traffic encounters*

Traffic is based on the co-operative activities on shared resources. Even if the traffic regulations and supporting infrastructure set the frame for actions, much of the practical coordination of traffic encounters take place with various ways of informal communication between the travellers. Blinkers are used not only for communicating the intended turning but also as a sign for a fellow driver about free road for overtaking or as a way to say thanks. People also show signs for other travellers through the windshield or flashes their lights (e.g., for warning or giving sign of their intention to overtake) etc.

The ways of communicate in the traffic encounters are, however, very limited and interpretation of the intended message is often difficult. The use of mobile technologies possibly combined with other ITS applications would enable richer means for communication in traffic, and thus, help people to better co-ordinate their actions and make traffic more optimized. To realise applications that enable people to enhanced communication in traffic encounters, requires research on multiple subject areas including social and cognitive sciences, innovative and non-distractive user interfaces, vehicle-to-vehicle communications etc.

6.5.2.4 *Social coordination of mobility*

The mobility of the urban commuters is not only based on the shortest selection of the fastest paths between the origins, possible intermediate destinations and final destinations. In the era of ubiquitous communications, people have already long coordinated their mobility patterns socially on the fly with their mobile phones [Ling+ 2002]. Group calendars are used to occupy slots from people's time budgets for meetings and when locations of meetings are understandable for others, also some geographic optimizations can be basis for arranging, e.g., adjoining meetings on same site. In addition, the recently emerged social location-based mobile services (e.g. Google Latitude, FourSquare) have brought new tools for people to follow the mobility activities taking place in their social networks and adjust their own activities with them in real-time.

Apart from mobile phone, all other tools for social networks to coordinate their mobility patterns in optimized way are still used in small scale within early adopter and power user groups. New tools and services to support social context-awareness and controlling one's presence and its publicity in her social networks are still needed to enable people to organize their mobility with respect to social needs in a more optimized way.

6.5.3 ***New mobility concepts***

Under this class of services fall those innovations that require not only technological advances but also somewhat revolutionary and new ways to realize the solutions for the mobility optimization. Many of the traffic services enable more effective enforcement of the rules and regulations, allow convenient access to traffic related services or provide traffic information in order to make traffic more fluid. The thinking in these applications is that the motivation to use those services is solely related to the usefulness of the services. The idea presented next takes this further: in addition to the usefulness of the service itself, it gives extra rewards to the people who change their traffic behaviour towards the traffic policies set, e.g., by the authorities.

6.5.3.1 *Incentive-based traffic optimization*

The European FP7 project "Sustainable Social Network Services for Transport" (SUNSET) [SUNSET 2012] is developing a concept where travellers, road authorities and other parties share information and provide positive incentives in order to tune people's mobility patterns more optimal and sustainable. The TRIPZOOM platform to be developed in the project allows citizens to share their personal mobility patterns via social networks and reward them with incentives in order to encourage them to utilize sustainable forms of transportation and to generate a win-win situation for all involved stakeholders (See Figure 25).

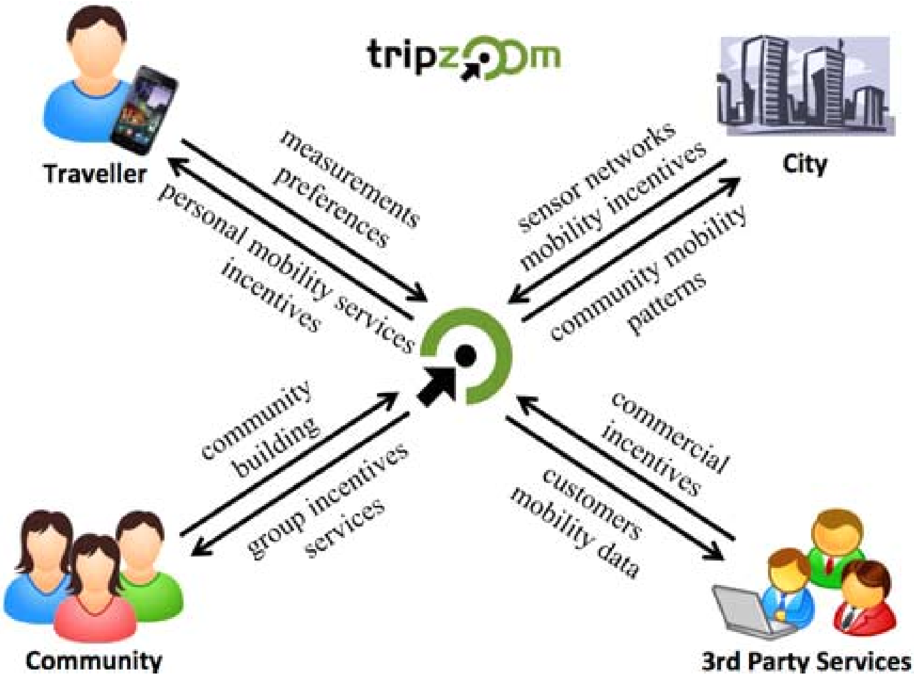

Figure 25. The TRIPZOOM ecosystem (from [Holleis+ 2012]).

The TRIPZOOM concept is based on sharing detailed, individual mobility profiles of citizens with city authorities, communities (e.g., employees of company, members of car sharing service) and commercial 3rd party stakeholders. It is consists of a network of Core Services guarded by *Proxy and Security Services*. User interfaces for different groups of users are provided with Mobile Clients, Web Portal, City Dashboard. In addition, connections to external services and data sources are provided. (See Figure 26)

The data for the mobility profiles are collected with smart phones allowing positioning and stored into the *Personal Mobility Store (PMS)*. In the same time, infrastructure sensing utilizing, e.g. different kind of sensors is used to collect real-time traffic data from infrastructure. The TRIPZOOM system then processes these data in *Mobility Pattern Detector (MPD)* to detect patterns for individuals, groups, places, regions, routes, or different kinds of vehicles.

Combining these two sources of traffic knowledge TRIPZOOM system enable different stakeholders to discover targets for optimization using *Mobility Pattern Visualizer (MPV)* and use *Incentive Market Place (IMP)* to dynamically create and manage incentive policies encouraging more sustainable and optimized traffic with incentives rewarding those travellers who change their traffic behaviour according to these policies.

According to [Holleis+ 2012], the incentive types that were found influential enough included:

- *Time*: efficient use, control, saving, and planning
- *Money*: save (e.g., discounts on transportation tickets) or even generate (e.g., coupons)
- *Information*: receive (real-time, personalized) information about progress, travel alternatives, ...
- *(Social) recognition*: of being green and healthy/fit; give feedback to and receive feedback from others

The Incentive Market Place component realizes the incentives as challenges to travellers. Challenges are defined as a set of rules (that promotes the objective or policy aiming at optimization) that the users of the TRIPZOOM system must fulfil in order to earn rewards. TRIPZOOM uses, e.g. a point scheme to integrate various offers to incentives provided by different stakeholders. E.g., a certain amount of points can be exchanged to access of transportation fare reduction, coupons worth of money, useful information or special badges as a recognition in some social networking system (like Foursquare).
TRIPZOOM provides its own social network implementation, *Relation, Identity, and Privacy Manager (RIP)* to manage users, social relations and groups as well as enforce privacy policies. Finally, *Social Network Connector (SNC)* connects TRIPZOOM to existing social networks like Facebook or FourSquare.

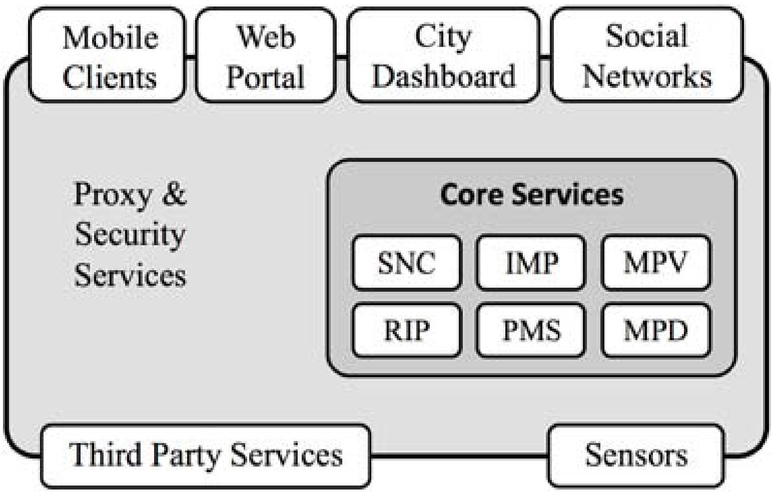

Figure 26. Main system components of TRIPZOOM (from [Holleis+ 2012]).

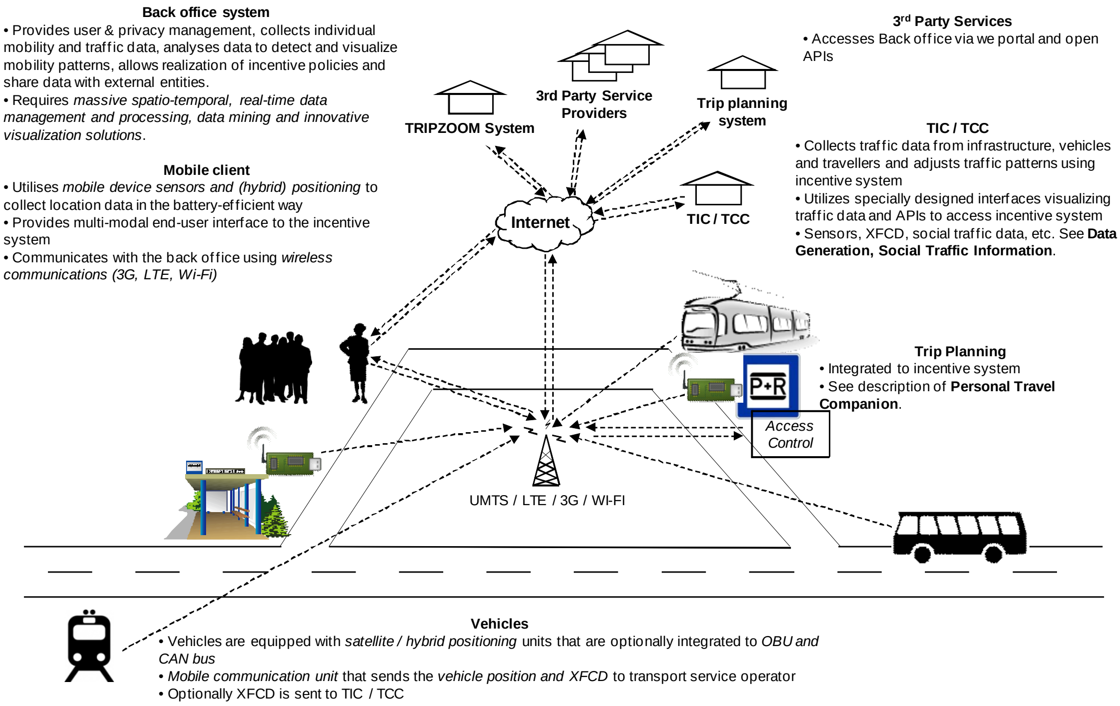

Figure 27. Incentive-based Traffic Optimization.

6.6 Urban logistics services

When great number of people is packed in densely populated urban areas the need of logistic optimization becomes of paramount importance. Fleet management, access control and route guidance are examples of existing services that optimize logistics. These applications and services are well advanced in the context of long-distance and inter-urban logistics – between big logistics centres – but the more tricky part of the logistic chain usually starts from the outskirts of the cities – the delivery for the few last miles. For example, in most cases all these services are too rigid to meet the requirements arising from the dynamic nature of the human activities which often leads to the situation where the logistics chain cannot reach the consignee. For that reason we have selected *Dynamic last mile delivery* as an example addressing this challenge. Another aspect that has been more or less lacking from the optimization of urban logistics, and urban transportation in general, is eco-friendliness. *Eco-driving* service portfolio has been selected as another example addressing just this aspect of optimization.

6.6.1 *Dynamic last mile delivery*

The dramatic increase of eCommerce (see *Virtual mobility services* later in this document) brings challenges to the logistics sector, and especially in last-mile logistics in metropolitan areas. An example of these challenges is the last-mile delivery directly to consignee by courier companies used widely in online retail shopping. Progress of the delivery can already often be followed using dedicated Internet service by postal and courier companies but still it is hard to predict what is the exact moment for the actual delivery to consignee. For that, reason it often the case that courier does not reach the consignee and delivery fails which leads to negotiations of the new time and place to drop the delivery. All this causes waste of time and resources as well as inconvenience to the customers.

One way to optimize the last-mile delivery to the consignee is to build a service and system to allow dynamic last mile delivery which allows consignees and courier companies to mutually coordinate the optimized last mile delivery. For example, [Li+ 2012] provides a use case scenario for an application enabling last mile delivery where time and place of the delivery can be negotiated dynamically. This is done by sharing relevant parts of the consignee's calendar or otherwise share information about his or her whereabouts and plans in the near future with the transport operator. In addition, consignees or transport operators may change the time and place of delivery if some unanticipated event prevents the already appointed delivery. Using this information, it is easier for the transport operator to optimize its activities to match the consignees' abilities to receive the delivery.

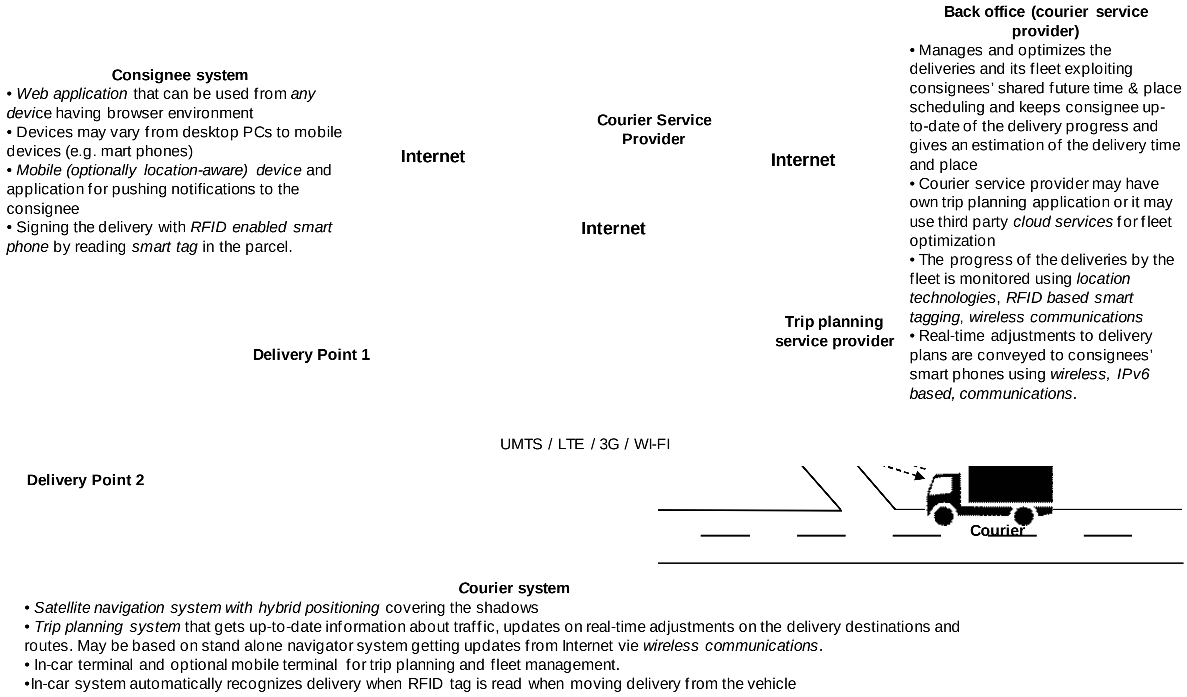

Figure 28. Dynamic last mile delivery

6.6.2 *Eco-driving*

The ongoing eCoMove project is targeting at reducing fuel consumption and CO_2-emissions with 20% by supporting drivers of both vehicles and trucks to drive more efficient, to plan their routes more efficient and traffic managers to manage traffic more efficiently. Information from road side units, traffic management centre, GIS systems containing attributes needed for eco-driving, and also from other vehicles are exchanged to determine the best route, the most efficient driving strategy and the optimal traffic management and control strategy and settings. [Schmits 2011] The overall system is presented in Figure 29.

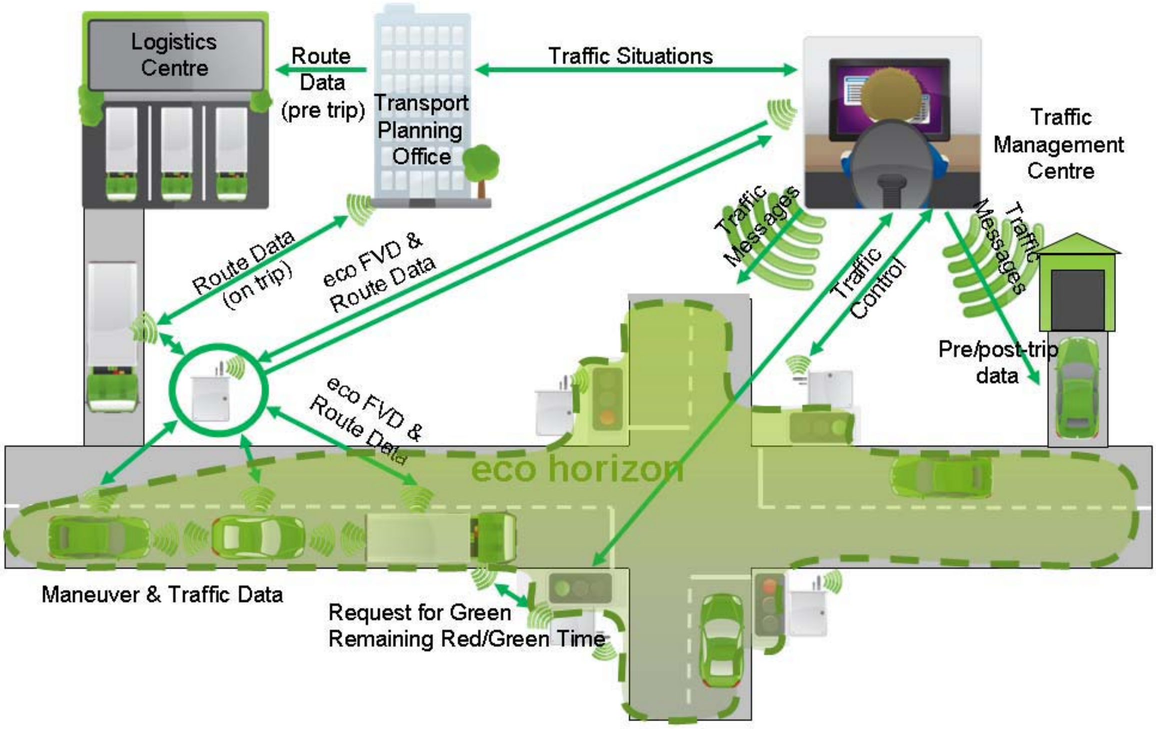

Figure 29. eCoMove - overall system concept (from: [Schmits 2011]).

The eCoMove project considers three application domains for ecological mobility:

1. Eco-driving support for passenger car drivers
2. Ecological freight transportation and logistics
3. Traffic management

The passenger car solutions motivate and coach car drivers eco-optimized driving. The system under development includes:

- trip planning in the most energy efficient way
- navigation via the most fuel efficient route
- driving support recommending the most efficient way to drive
- monitoring the vehicle state and its energy consumption to find inefficiencies and notifying the driver about them
- post trip feedback to the driver about the eco-efficiency of the past trip

In addition, the system collects extended floating car data (XFCD) anonymously to traffic control centres and other vehicles.
For freight and logistics, system offers services and applications similar to passenger car drivers but tailored for professional heavy vehicles and fleet management:

- tour planning for the most efficient tour station sequence for given transport orders and fulfilling given restrictions as well as checking its conformance to the Local Authority policy requirements.

- navigation through most fuel efficient route

- checking the status of the vehicle (with the help of sensors and manual check list) for fuel optimization, guiding the driver on trip, and giving feedback after the trip.

Traffic management concentrates on the eco-optimization of the traffic network and its resources as a whole. It provides services, e.g., for:

- route optimization taking into account the current, future and desired traffic state and the route pattern;

- parking optimization by assigning the vehicles to different available parking locations en routes considering the optimal distribution over the area;

- "green waves" by synchronizing subsequent signalised intersections, providing direct driver assistance and using cooperative technologies to obtain information about the spatiotemporal state of moving platoons and their composition;

- balancing the needs of the approaching vehicles in intersections by controlling traffic signals in a way that minimises fuel consumption without affecting safety;

- helping the merging of the traffic flows in highway ramps giving drivers advice for their speed adjustment;

- etc.

As seen from the overall system concept (Figure 29) and the list of applications and services (Figure 30. eCoMove services aimed to reduce inefficient fuel consumption. (From: [Schmits 2011])Figure 30), eCoMove is a complex system consisting of multiple stakeholders and subsystems in vehicles, back offices, road side units as well as personal computing devices. It utilizes IEEE 802.11p communications for V2I and V2V communication and cellular networks for other wireless communication needs. The communication architecture in Figure 31 shows the main protocol standards used in communication.

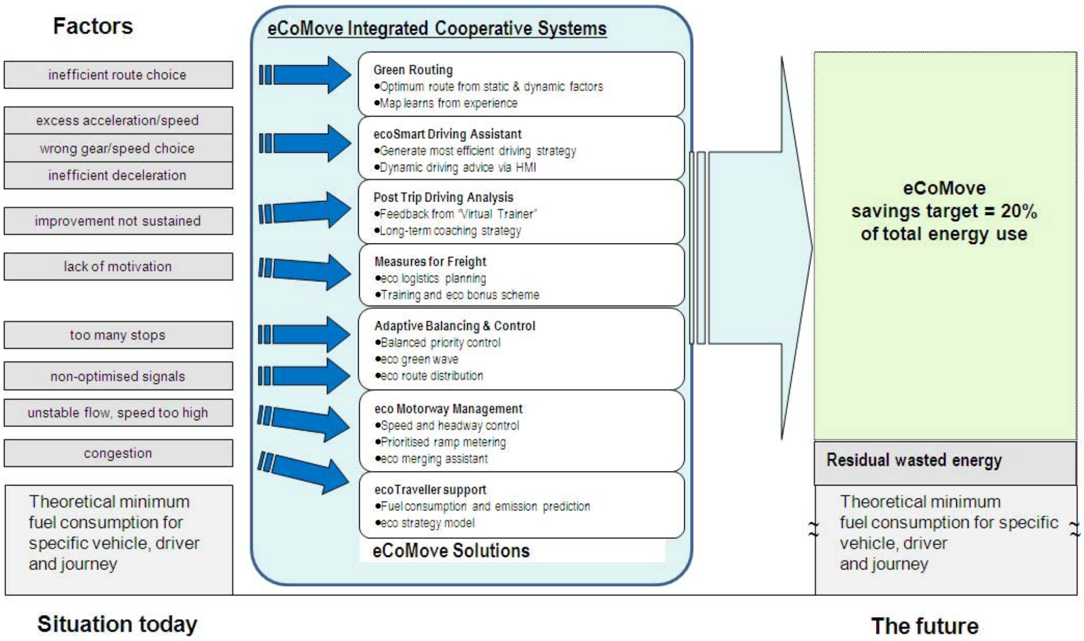

Figure 30. eCoMove services aimed to reduce inefficient fuel consumption. (From: [Schmits 2011])

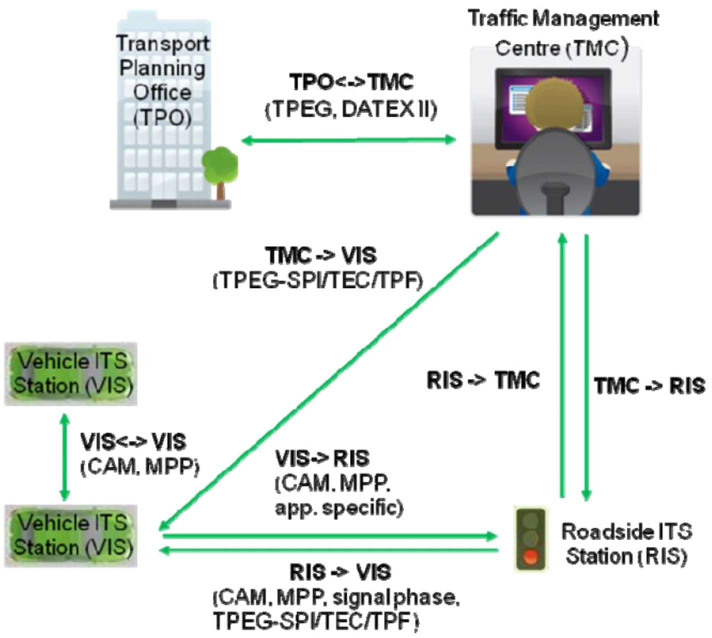

Figure 31. eCoMove communication architecture. (From: [Schmits 2011])

6.7 Urban traffic management services

Urban traffic management aims at maximizing the urban traffic system potential and in the same time increase safety and enforce selected traffic policies. It aims at forming a holistic picture of the traffic network and the traffic flows with the help of different kinds of data sources residing in the urban (traffic) infrastructure (cameras, sensors etc.) and then based on the analysis of these data to optimize the traffic. The optimization may take place in real-time by using, e.g. remotely controllable roadside signalling, or in long term by means of urban planning and new traffic policies.

Urban traffic management has existed decades and large traffic control rooms with tens or hundreds of displays are familiar to most of us. Still, vehicles and their drivers are very loosely connected to this management, if at all. At best, people get recommendations through the morning programs from their car radios or through the variable message signs. For that reason, we have selected two examples that tie the vehicles and their drivers better to the holistic picture gained through the co-operative urban traffic management. *Co-operative traffic signal control* adjusts the traffic signalling in real-time to maximize the throughput of the traffic network and informs drivers to behave co-operatively by adjusting their traffic behaviour to realize the optimizations. *Speed management* or Intelligent Speed Adaptation (ISA), in turn, is an old idea that has been implemented and tested in several pilot projects as well as studied to be effective way to reduce speeding, but still not realized in large scale anywhere. Speed management or Intelligent Speed Adaptation belongs to the family of services and applications falling under the banner *automated driving* (Figure 32). However, apart from the speed management, we do not review automated driving more closely since separate report solely concentrating on this topic exists [Nooij+ 2011].

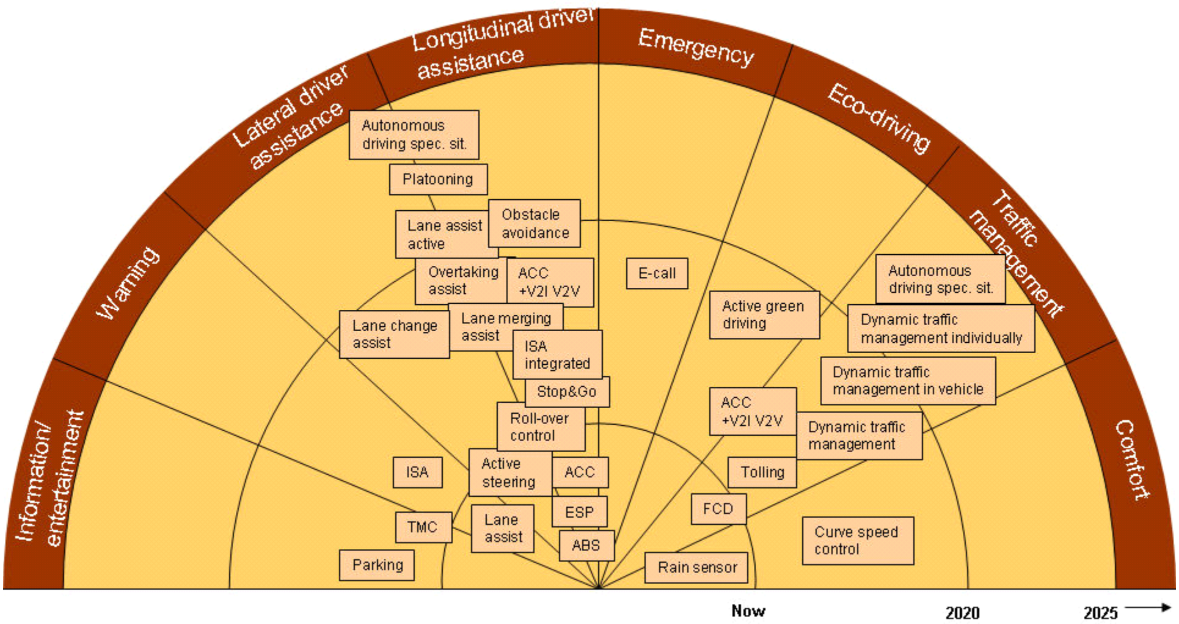

Figure 32. The current and possible future applications based on automated driving. [Nooij+ 2011]

Third example service *Dynamic and predictive parking service* in this section brings together several more or less existing services in order to address the parking problem in cities. It emphasizes the importance to meet different closely related parking related needs by integrating the services to a service bundle that serves the whole mobility process where parking is involved – something that has not been realized anywhere.

6.7.1 *Cooperative traffic signal control*

In the urban traffic signals, i.e., electrically operated traffic control devices (often identified with traffic lights but consisting also other kinds of signalling devices) are used to control competing flows of traffic, thus adding safety and efficiency of the traffic. Increased efficiency (which also means less, e.g. CO_2 emissions and noise), however, is realized only when the traffic signalling is adjusted in a right way.

Cooperative traffic signalling control is one proposed way to optimize the efficiency of traffic signalling [Li+ 2012], [Bottero+ 2011]. It uses ad-hoc networks to create vehicle to infrastructure communication (V2I) in order to offer drivers a recommended speed to avoid stopping, and adapting the traffic signals to the real demand in real time. The system uses information both from the vehicles and from the infrastructure to compute strategies to achieve the optimization of the network operation and controls the traffic signal network according to computed strategies.

The functioning of the system is roughly the following:

1. Road side unit (RSU) receives data (e.g., speed, type of vehicle etc.) from the vehicle.

2. RSU send data to Traffic Control Centre (TCC).

3. TCC calculates optimal green wave parameters for the vehicle (considering information received from other vehicles and infrastructure).

4. TCC distributes the green wave control parameters to traffic light controllers.

5. Traffic light controller alters the traffic signal intervals accordingly.

6. Vehicles are provided with information of optimal speeds for green waves and waiting times in case of stopping in red lights.

According to [Bottero+ 2011] main technological enablers include cloud computing and Internet of Things. The first is needed for the storing massive real time data and making real-time computations on that. The latter is needed to retrieve and filter the sensor information coming from vehicles and traffic management infrastructure. In addition to this, vehicles must be able to communicate with Road Side Units (RSUs) using Dedicated Short Range Communications (DSRC) / IEEE802.11p. Figure 33 depicts the general architecture of the system.

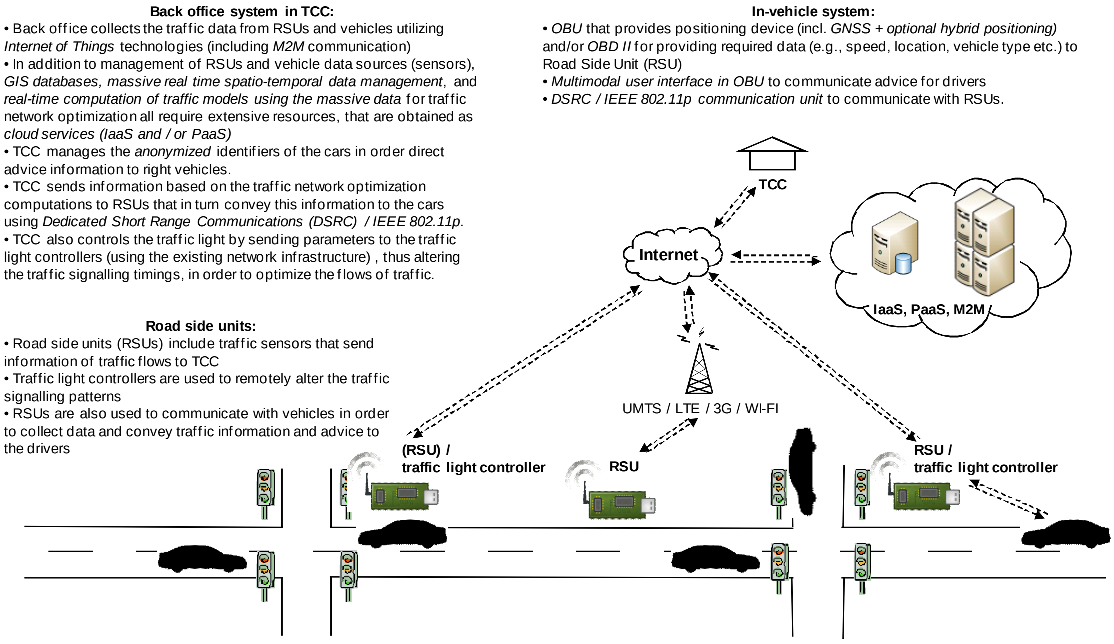

Figure 33. Cooperative traffic signal control.

6.7.2 *Speed management*

Speeding is a major cause of traffic crashes and the risk of crashes is emphasized on the roads with complex traffic situation [EC 2012b], [SWOV 2012], which emphasizes the need of speeding prevention in urban areas. Intelligent Speeding Adaptation / Assistance (ISA), that is one application in the automated driving application family, has proposed to assist drivers to improve compliance with speed limits while driving motorized vehicles. The general idea of the system is that it tracks the position of the vehicle, compares the speed of the vehicle to the speed limit on the area and gives feedback to the driver or even automatically restricts the speed of the vehicle if the speed limit is violated. Overview of the different types of the ISA systems with respect to level of driver support and nature of feedback can be found in Table 19.

ISA systems have been developed and their impacts to traffic safety have been studied extensively in last 20 years. The basic technology for the implementation of the ISA systems is available and the results of the studies indicate that ISA would clearly help to increase traffic safety. However, adoption of ISA as a mainstream safety feature in cars is mostly in stagnation.

Level of support	Type of feedback	Feedback
Informing	Mostly visual	The speed limit is displayed and the driver is reminded of changes in the speed limit.
Warning (open)	Visual/auditory	The system warns the driver when he exceeds the posted speed limit at a given location. The driver himself decides whether to use or ignore this information and to adjust his speed.
Intervening (half-open)	Haptic throttle (moderate/low force feedback)	The driver gets a force feedback through the accelerator if he tries to exceed the speed limit. If applying sufficient force, it is possible to driver faster than the limit.
Automatic control i.e. speed limiter (closed)	Haptic throttle (strong force feedback) and Dead throttle	The maximum speed of the vehicle is automatically limited to the speed limit in force. Driver's request for speeds beyond the speed limit is simply ignored.

Table 19. Overview of different variants of ISA systems [SWOV 2010]

The emergence of the features of ISA systems have, however, emerged in commonly used navigators which may (optionally) inform the user about the current speed limit if it is exceeded. In addition, few commercial products that has bypassed the slow progress of governmental initiatives have emerged in Australia. SpeedAlert [SpeedAlert 2012] is a passive ISA product that somewhat extends the speed information features of typical car navigation systems, while SpeedShield [SpeedShield 2012] that can be installed to cars to intervene and control the vehicle speed to be no faster than the posted speed limit for that section of roadway. The first one is targeted to all car drivers and the latter one for vehicle fleet operations. Despite of these rare cases and passive features in navigators or smart phone applications (like Coredination [Coredination 2012]), ISA is still emerging service in large scale.

Technically, the main alternatives to realize ISA [OECD 2006] are:

- ISA based on autonomous navigation (autonomous ISA).
- ISA based on roadside posts (dynamic or co-operative ISA).
- Combinations of the two above.

ISA based on autonomous navigation that is usually GNSS based but also be complemented, e.g., with dead reckoning with the help of sensors where no GNSS coverage is limited. A local speed limit database is kept in the on-board system, based on information from a central speed limit database. Updates are downloaded using wireless telecom or from a website. This is the way currently widely available navigators realize the passive, informative ISA. What is missing is real time update of the dynamically changing or temporary speed limits for navigation systems. This requires, that the central speed database is made aware of every dynamically changing speed limit on the road network and that these updates are conveyed to the drivers in the area in question. This in turn, requires that every stakeholder who has right to (temporarily) change the speed limit in some part of the road network is responsible for the speed database update. This is, naturally, more organisational than technical challenge in most cases.

ISA based on the roadside posts exploits the speed limit information transmitted to OBUs in cars by traffic infrastructure, namely roadside units attached to speed limit signs. Roadside units and dynamic traffic signs, in turn, can be controlled by Traffic Coordination Centres (TCC) or locally, e.g., by the road works crew.

Currently, the first alternative is widely used but the problem is that dynamic speed limits (e.g., due to road works or bad weather conditions) cannot be taken into account. The latter option, in turn, would require alteration of the infrastructure with numerous road side units and is not feasible solution alone. Combination of these two main approaches complementing each other with an addition of continuous location-aware updates of on-board speed limit data (via long range wireless communications) would enhance current service based on static speed limit data. The SpeedAlert project [SpeedAlert 2005] that did not use the term ISA at that time has defined such a system (but used their own term: *speed-alert*). Figure 34 shows the still valid functional architecture for ISA system developed by the SpeedAlert consortium already in 2005.

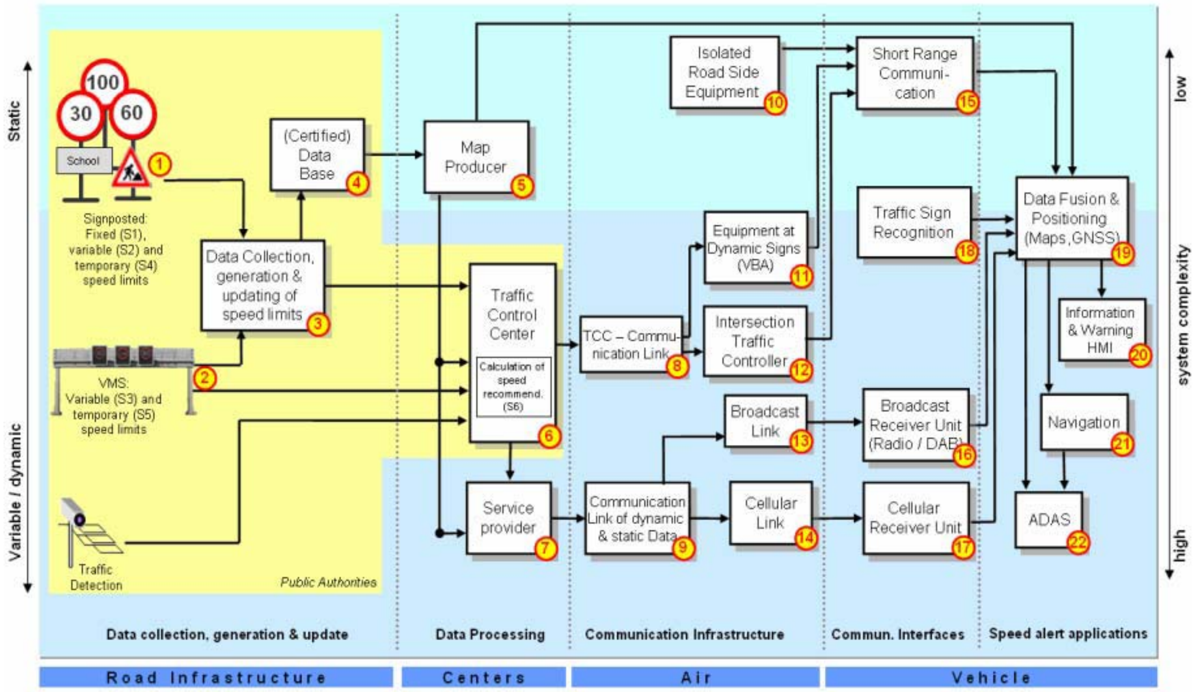

Figure 34. The SpeedAlert functional architecture (from [SpeedAlert 2005]).

The emergence of active ISA including in car systems where in-car system actively intervenes driver's decisions on speed or even automatically limits the speed (included in the functional block ADAS, Advanced Driver Assistance Systems, in Figure 34) is also certainly technically possible and tested option (instead of passive ISA). However, Vienna Convention on Road Traffic [Vienna 1968], as written now, prevents implementation of the systems that take control completely away from the driver. For that reason, in the next 10 years we hardly see systems that force drivers to keep the speed inside the limits. However, milder systems giving, e.g., force feedback may well emerge. The SpeedAlert project consortium saw in 2005 the evolution of ISA as 4 different kinds of scenarios corresponding to different technical evolution branches (see but did not gave exact time scale for the milestones in the scenarios. However in their report [SpeedAlert 2005] they foresee:

> *Considering the available and upcoming technologies, market introduction of first generation speed-alert applications in 2006 seems possible (autonomous systems). Further developed systems with incremental map updates will be introduced later. A possible time frame is estimated as 2009. Cooperative systems with the highest sophistication of situation adapted speed alert and recommendation functionality may be available around the year 2015.*

They might have been quite optimistic with respect to the last kind of systems, though.

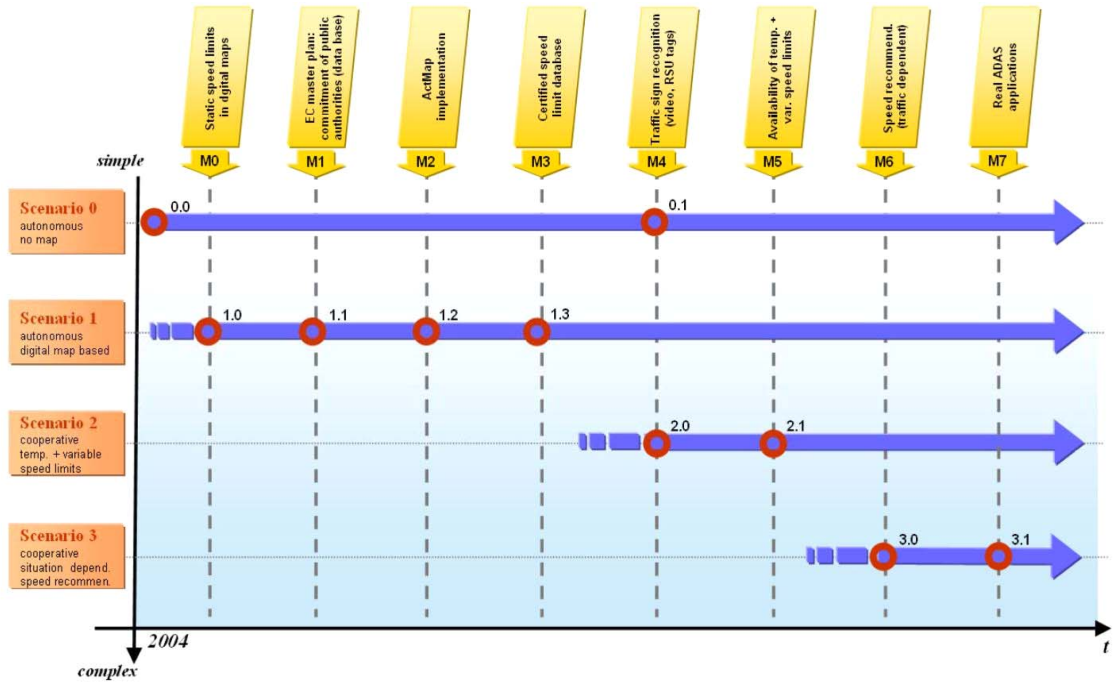

Figure 35. Evolution of technical scenarios related to ISA. (From: [SpeedAlert 2005])

6.7.3 *Dynamic and predictive parking service*

Finding a parking place in almost any metropolitan area takes a lot of time as well as increases traffic congestion and CO_2 emissions. For example, in Barcelona downtown finding a parking place takes typically 15 minutes, and reducing that time to 12 minutes would reduce CO_2 emissions 400 tons/day [Correia+ 2011]. For that reason, public parking places should be managed more efficiently and services helping users to find parking places nearby their destinations should be developed – not forgetting convenient park & ride solutions that reduce personal car traffic from city centres.

VTT has modelled parking related activities in SUNTIO2 project (Multi-Service Platform for Transport and Logistics) [SUNTIO2 2012]. Figure 36 illustrates some of the use cases that are closely related to parking activity. Currently some of these activities are supported with separate proprietary services and in many cases activities are poorly supported. For example, finding a parking place may be partially supported by navigators that include locations of some of the parking areas, but currently availability or prediction of availability of the parking places cannot be obtained from anywhere. Reservation of the parking place that would greatly help park & ride based trip planning is also not usually possible. The other problem is that integrated services that would support the parking process from beginning to end or better yet: to embed parking process to complete mobility service package that includes all the mobility related services in a one stop shop (see [VTT 2011]).

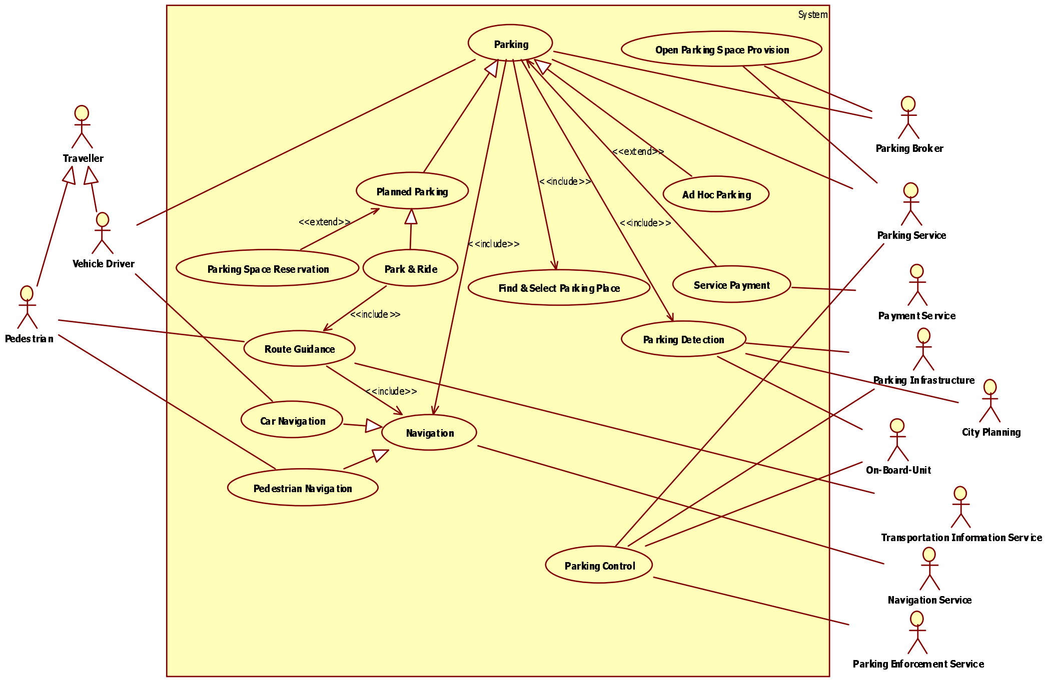

Figure 36. Central parking related use cases.

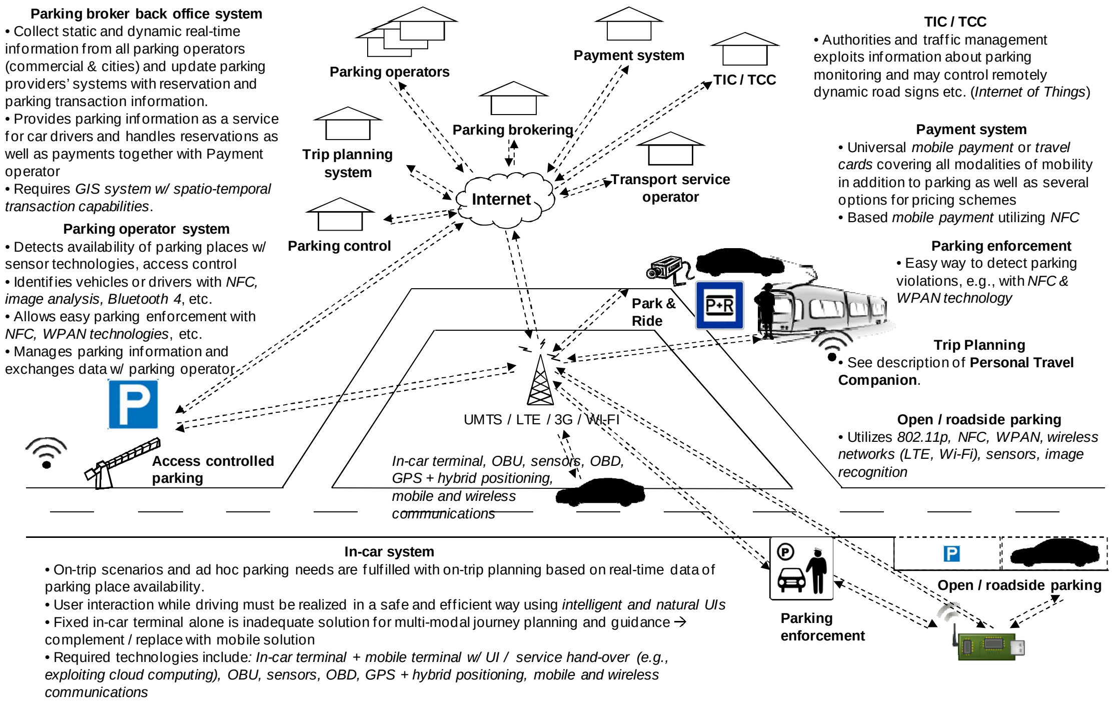

Figure 37. Dynamic and predictive parking.

6.8 **Virtual mobility services**

Virtual mobility in work utilizes ICT to reduce physical mobility needs, e.g., by

- moving work where the workers are instead of moving workers to work (telework/telecommuting)
- substituting face-to-face meetings by ICT mediated meetings (e.g., video conferences and conference calls)
- supporting work in geographically distributed teams (virtual teams)

The concept of "telecommuting" or "telecommunications-augmented decentralization" dates back nearly four decades [Nilles 1975] and has since then telework has become a significant feature in the working environment. For example, in 2005 7% of the European working population teleworked at least quarter of their working time [ECWS 2010]. Companies reduce costs by substituting business trips with video conferences and arrange their teams to work round the clock in different time zones with globally distributed teams. In addition, members of the international project teams use extensively Computer Mediated Communication and CSCW tools to organize their work.

Virtual mobility is strongly present also in other areas of life. Electronic commerce, where buying and selling products is done using computer networks and online services, comprises currently 3.4 % of all retail sales in Europe. It has been seen beneficial in many ways and therefore European Commission has adopted a Communication presenting 16 targeted initiatives aimed at doubling the share of e-commerce in retail sales and that of the Internet sector in European GDP (currently less than 3 %) by 2015 [EC 2012a]. In the same time, The Forrester Research Inc. predicts that online retail sales in 17 major European markets will increase from 96,706 million euros in 2011 to 171,957 million euros by 2016, a compound annual growth rate of 12.2%.

The government information and services are increasingly provided for citizens using e-Government services. This development, while e-Government can be said to be existing widely, varies greatly in different countries and e.g. UN maintains a ranking of the e-Government readiness in world countries. (See [UN 2012]).

Also other services are already widely provided as "teleservices" decreasing peoples' need to travel. This is the case for example in health and medical services. An example of the advances in these areas is telesurgery or robotic surgery that has already become an established part of clinical surgery. [Rosen 2011]

Although, services and application supporting virtual mobility are omnipresent, the need for development in this area is far from complete. For example, telepresence which allows people to feel as if they were present in some remote location, has been widely used in teleconferences. However, without extremely expensive telepresence rooms the feel of being present is compromised because of too small and low resolution screens for natural view and insufficient quality of sound with illusion of directionality and audible perspective. Therefore, telepresence applications and services have been usually restricted to formal environments dedicated to meetings and lacking, e.g. from homes or public spaces. The future technology developments in the display technologies as well as convergence of home electronics and ICT may change this. For that reason, we bring up an example of general enabling application / service that may contribute to virtual mobility: *Consumer telepresence*.

6.8.1 *Consumer telepresence*

The popularity of VOIP calls and video conferencing over internet using services like Skype gives clear indication that there is potential for the growth of different kinds of consumer oriented telepresence applications and services. This holds not only for those existing applications and services replacing telephony but also for high-end solutions that provide more realistic presence formerly available only using hugely expensive corporate solutions. The service functionality itself is simple: provide high quality audiovisual communications between two or more users. Simplicity does not always yield easy realisation, which can still be experienced even with high end corporate systems that do not always work as intended. Sufficient bandwidth with multiple Megabits per second upstream as well as high resolution cameras and displays (possibly constructed as arrays of displays) and spatial sound systems have been out of consumers' reach till these days. However, the situation is changing. Rapidly increasing bandwidth to homes, cheap high resolution displays, and convergence of the consumer electronics (e.g. home theatres) and Internet technologies are likely to bring telepresence to homes in the quality previously available only with systems costing 100 k€s and up. However, the asymmetric broadband technologies may cause problems for this development.

The potential of consumer telepresence was also seen by Cisco that launched their *ūmi* telepresence system in 2010 [Lichtman 2010], [Cisco 2012] targeted to home use. However, entering to consumer markets with their telepresence product proved to be a disaster (e.g., because of their pricing) and it was discontinued [Chaffin 2011]. However, solutions based on the Internet technologies and consumer electronics are emerging. One example is *telyHD* [Tely 2012] that brings Skype video calls to consumers' living rooms via HD televisions, WiFi equipped cameras.

There is still way to go to realistic telepresence but in next ten years development in key technology areas (displays, broadband, home electronics) are likely to take this development forward. This in turn, opens new opportunities for service build on the telepresence. Personal communication, services for elderly people willing to stay in their homes, healthcare services, eCommerce are few examples of potential applications. In addition, affordable telepresence in working places enables support for informal encounters between the spatially distributed members of working community, which is an invaluable addition to current formally scheduled teleconferences letting workers to communicate with each other in ad hoc situations that resemble bumping to each other in the cafeteria or corridor.

6.9 Booking and payment

Booking and payment create a general application area that penetrates through all service bundles. In the examples below we concentrate on two services that will with great certainty emerge in large scale during the next years: *Mobile payment* and *Mobile ticketing*. Both services are built with the help of smartphones equipped with NFC technology. Mobile payment will complement (or even replace in some day) payment cards as means of payment transactions bringing along new features not available now with cards. Mobile ticketing is developed to replace currently used tickets needed for travelling (ranging from paper tickets to smart cards) and adding several add-on services above the currently possible ones. In addition, services build using NFC equipped mobile phones enable travelling solutions that do not need tickets at all – not even in their digital forms. We give an example on this kind pilot system.

6.9.1 *Mobile Payment*

Mobile phones have evolved from simple portable voice communication devices to smart phones where voice calls are not even the primary feature in the device anymore for many users. Different kinds of computer mediated communication and social media applications, personal information management, navigation, photographing and video recording among the number of other applications and features have made smart phones perhaps the most important personal multi-functional assets since PC. What is notable is that smartphones are predicted to account for more than half of the world's phone market by 2015 [IHS 2012]. Since smart phones are almost always carried along it is no surprise that it has become also a promising asset for payment as well as also as a *mobile wallet* that stores and manages other kinds of personal cards (like ID cards, driver's licences, loyalty and memberships cards etc.) in addition to payment cards.
Using mobile phone as means of payment fall into two main categories:

- *Remote Mobile Payment* take place online, in which the mobile phone is used as a device to authenticate personal information stored remotely, using mobile phone data channels (e.g., SMS, WAP, USSD protocol).

- *Proximity Mobile Payment* (also called Mobile Contactless Payment, MCP) refers to a payment to a physical merchant that is initiated from an NFC-enabled mobile phone (containing personal ID information) held in close proximity (within a few centimetres) to the merchant's point-of-sale equipment.

From these latter one has gained recently most attention as a future payment system as it has been endorsed by major players in the market, and thus, we concentrate on this as an example of future payment services. It utilizes NFC-enabled mobile phones by incorporating smart chips that allow the phones to securely store the payment application and consumer account information and to use the information as a "virtual payment card." These smart chips can be present in many forms, e.g., as smart card based subscriber identity module (SIM) cards, embedded secure elements in the phone, and secure digital (SD) memory cards. NFC payment transactions between a mobile phone and a point-of-sales (POS) terminal use the standard contactless communication protocols currently used by contactless credit and debit cards. [SCA 2009]
Proximity Mobile Payment with NFC technology has been studied and piloted intensively and first launches have been done (see, e.g., [Garside 2011], [Graziano 2012]). Currently the mobile payment scene is in its infancy and fragmented and multiple players are emerging to the market. In addition, current solutions have been found vulnerable [Wagstaff 2012].

However, the breakthrough of the mobile payments is expected to happen in upcoming years according to major market research analysts.

European Payment Council that is the coordination and decision-making body of the European banking industry in relation to payments have prioritized analysed the most important mobile payment scenarios [EPC 2012] as well as compiled implementation interoperability guidelines covering service, technical and security aspects for the stakeholders in Single Euro Payments Area (SEPA) [EPC 2011]. Their aim is to leverage as much as possible the shared infrastructure for contactless SEPA card payments, mobile contactless payments are based only on the usage of NFC technology in card-emulation mode (where NFC based mobile phone works like contactless card).

The use cases described in [EPC 2012] show very well how the Mobile Contactless Payment (a.k.a. Proximity Mobile Payment) takes place. Figure 38 shows two basic MPC scenarios from the end-user point of view.

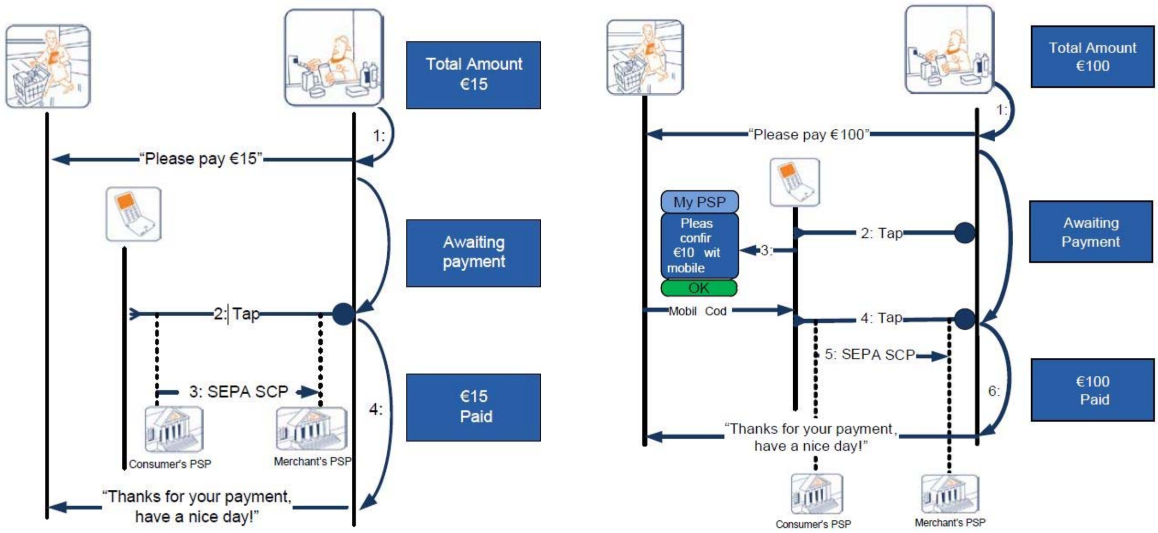

Figure 38. Basic Mobile Contactless Payment scenarios by EPC (from [EPC 2012])

The first scenario for small payments follows the following scheme [EPC 2012]:

1. The merchant starts by entering the transaction amount to the Point of Interaction (POI) terminal.
2. The payment card, which is preselected on the consumer's mobile phone, is automatically used for the payment. Therefore, to confirm the payment transaction, the consumer only needs to tap the mobile phone on the NFC-enabled POI terminal area.
3. Thereafter, the transaction is processed as a standard SEPA Card Payment (SCP) transaction.
4. The merchant is able to check the payment.

Payment for payments involving greater sums is somewhat more complex:

1. The merchant starts by entering the transaction amount to the POI terminal.
2. The consumer taps his/her mobile phone on the NFC-enabled POI terminal area.

3. The payment card which is pre-selected on the consumer's mobile phone is automatically used for the payment. Therefore, to confirm the payment transaction, the consumer only needs to enter his/her mobile code onto the mobile phone.
4. Next, the consumer taps the mobile phone a second time on the NFC-enabled POI terminal area.
5. The transaction is then processed as standard SCP transaction.
6. The merchant is able to check the payment.

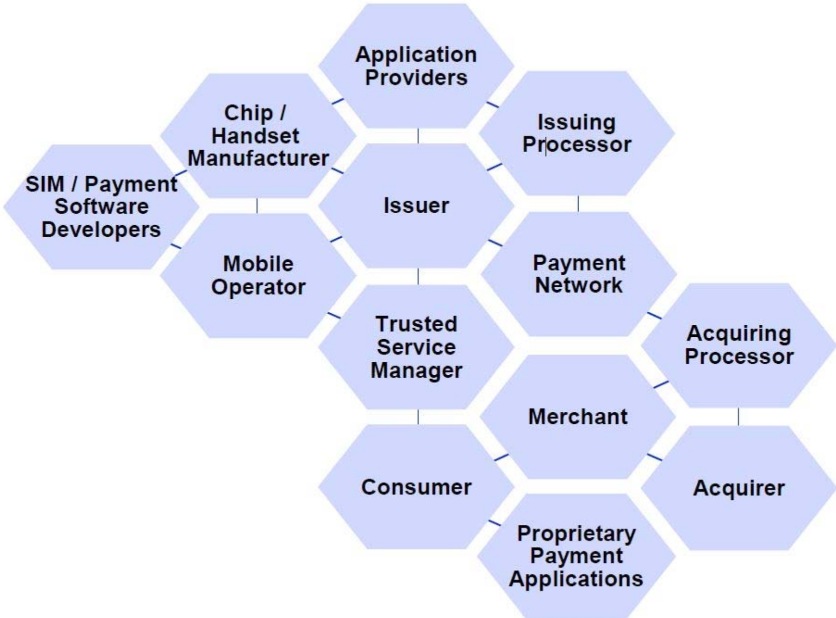

Figure 39. Stakeholders possibly involved in the Mobile Contactless Payment (From: [SCA 2007])

The MPC business environment is complex and the network of great number of stakeholders (see Figure 39) makes the mutual agreement on the details of the payment solution difficult. This complexity is also reflected to the overall system needed to implement the payment system. However, most of the back office systems already exist and MPC brings only a new entry point to them. Detailed descriptions of the required back office systems for payment, banking and clearance are thus out of scope in this document.

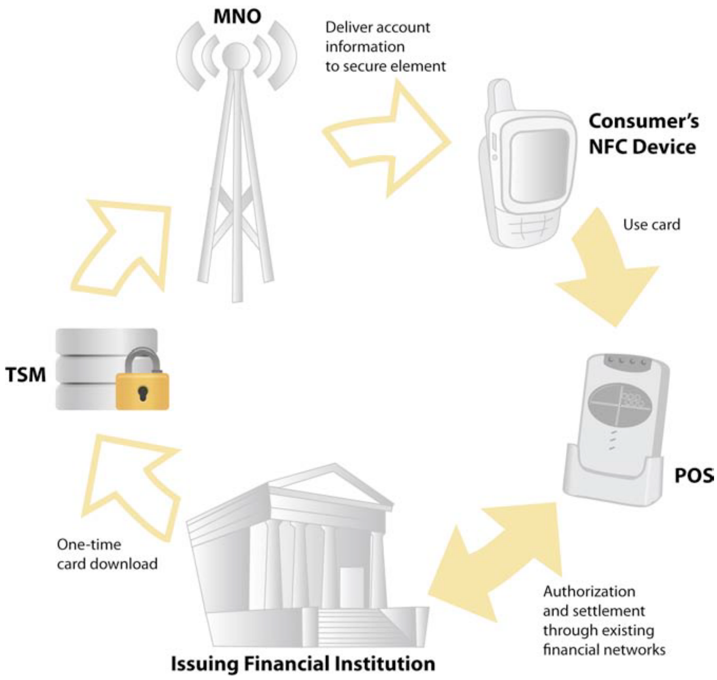

Figure 40. Collaboration model of the MCP stakeholders (from [SCA 2009]).

Figure 40 illustrates the entities involved in one implementation of the MCP payment ecosystem and shows the flow of information for the issuing financial institution to provision the consumer's payment account information to the phone and for the consumer to use the phone to make a proximity mobile payment using the NFC reader device at the Point of Service (POS). This model posits collaboration among financial institutions, the Mobile Network Operator (MNO), and other stakeholders in the mobile payments ecosystem, including (potentially) a trusted third party who manages the deployment of mobile applications, i.e., the Trusted Service Manager (TSM). In this figure from [SCA 2009], solid arrows are used to indicate payment related transactions, while outline arrows are used to indicate actions related to the personalization of the application.

From the technical point of view, key technologies include various cryptographic and key management solutions for securing keep sensitive payment applications and account data secure in the mobile payment ecosystem. In addition, mobile phones must have Secure Element (SE) that is a platform where applications can be installed, personalized and managed, preferably over-the-air. It is a combination of hardware, software, interfaces and protocols that enable the secure storage and usage of credentials for payments, authentication and other services.

Using a TSM for proximity mobile payments allows issuing banks or other service providers to abstract themselves from the complexities of the mobile landscape while enabling consumers to achieve the maximum benefit from a broad-service ecosystem.

Proximity mobile payments do not require account data to be stored on a physical card. The data originates at an issuing bank and is passed securely through a TSM to the secure element in the mobile handset using radio access network (RAN) provided by MNO. The data is protected by (multiple layers of) cryptography throughout the process and the TSM has a critical role in managing the security of the process. See Figure 41 for an example of security architecture of the MCP.

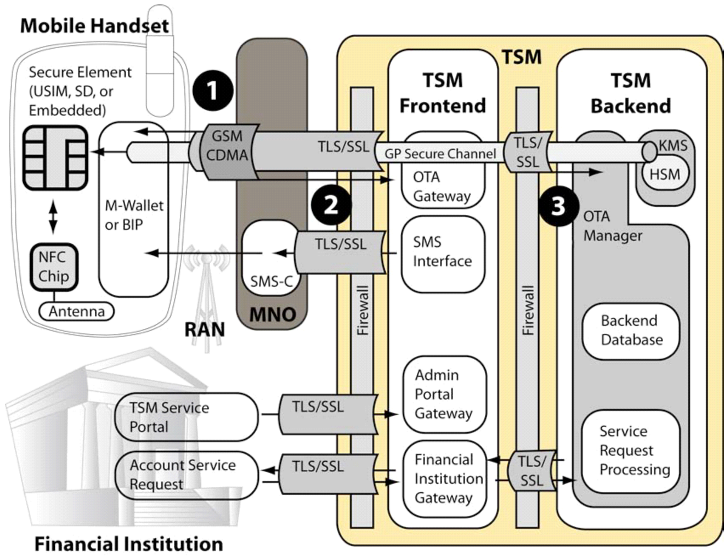

Figure 41. An example of mobile payment security architecture based involving Trusted Service Manager (TSM). (From: [SCA 2009])

The benefits of the emerging contactless payment solutions from the traffic optimization point come from the efficiency and convenience of the payment. (See Using mobile phone (instead of contactless cards) adds opportunities for add-on services and, for example, an easy way to peer-to-peer funds transfer (from on NFC-enabled phone to another). Mobile Wallets will add solutions that allow end-users not only to pay with their mobile phone but manage all kinds of information that is currently in tens of separate cards in our physical wallets (ID cards, loyalty cards, membership cards, tickets etc.).

6.9.2 *Mobile ticketing and ticketless travelling*

In addition to mobile payment, mobile ticketing has been envisioned to offer great value for travellers and public transport operators. Several pilots have been conducted all over the world to test technical feasibility and user acceptance. Touch&Travel [T&T 2012] is a large scale pilot involving 300 travellers and covering long-distance trains between the cities Berlin, Cologne, Dusseldorf and Frankfurt, as well as selected regional trains, the metro and trams in Berlin, and all means of transport – including busses and a ferry – in Potsdam. The system offers the travellers simple and flexible ticketless access to multimodal mobility across different cities and regions in Germany using NFC enabled phones. Figure 42 depicts the operation of the Touch&Travel pilot and shows how the future mobile ticketless multimodal travelling may work.

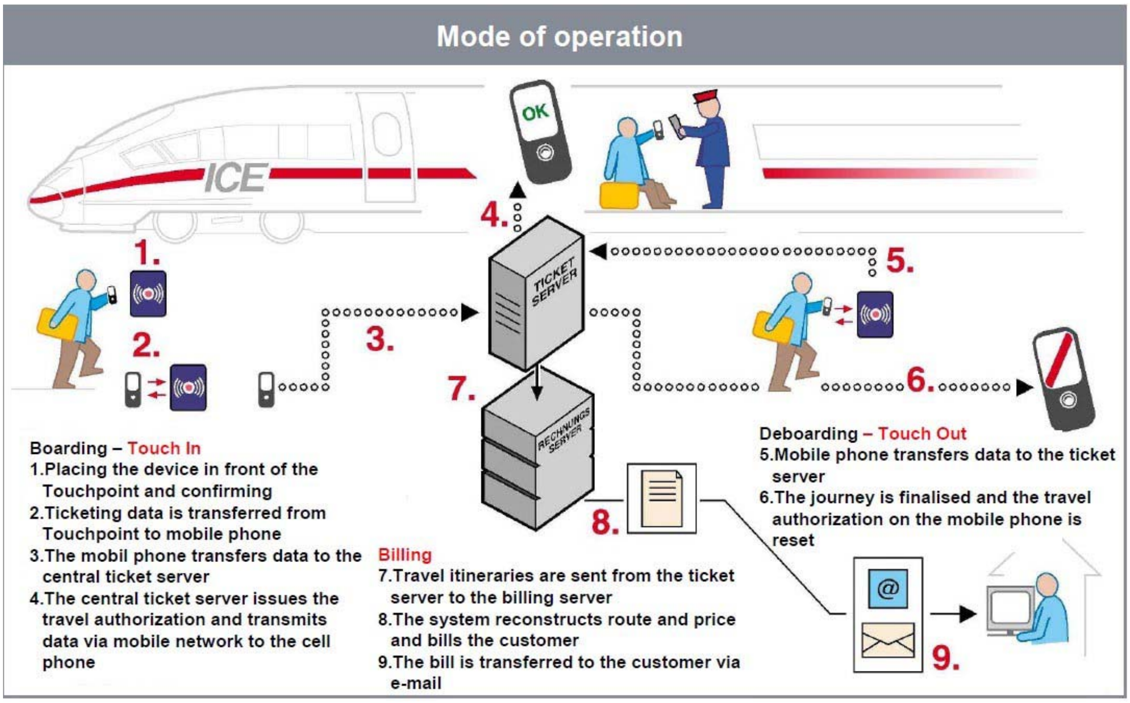

Figure 42. Operation of the Touch&Travel pilot (from: [NFCF 2011])

Mobile ticketing uses the same technologies than mobile payment but the underlying service infrastructure and stakeholder network is not necessarily as complex. Figure 43 depicts the high level service architecture for mobile ticketing in public transportation [NFCF 2011].

The tickets are stored in the mobile phone, e.g., in one of the following ways:

- A handset manufacturer can provide NFC-enabled phones with embedded secure elements
- SIM manufacturers can provide the SIM cards, via the mobile network operators, needed to store ticket applications
- Secure Digital card manufacturers can offer SD cards, when the ticket is stored in a pop-out card

Mobile Network Operator (MNO) provides connectivity to the infrastructure. Over-the-air (OTA) service provider allows travellers to download purchased tickets, pay-as-you-go stored value, or new applications (most often the mobile operator or TSM). A Trusted Service Manager (TSM) is needed to control security of the applications, data files, and associated security keys that have been downloaded to the secure element on the NFC-enabled phone (as in mobile payment).

The benefits of the mobile NFC based ticketing or ticketless solutions offer are similar to the ones in mobile payment. In public transportation, these benefits are topped with numerous related add-on applications that may help people while mobile (e.g., pre-trip / on-trip trip planning, navigational aids, taxi or park&ride services, location-based services etc.).

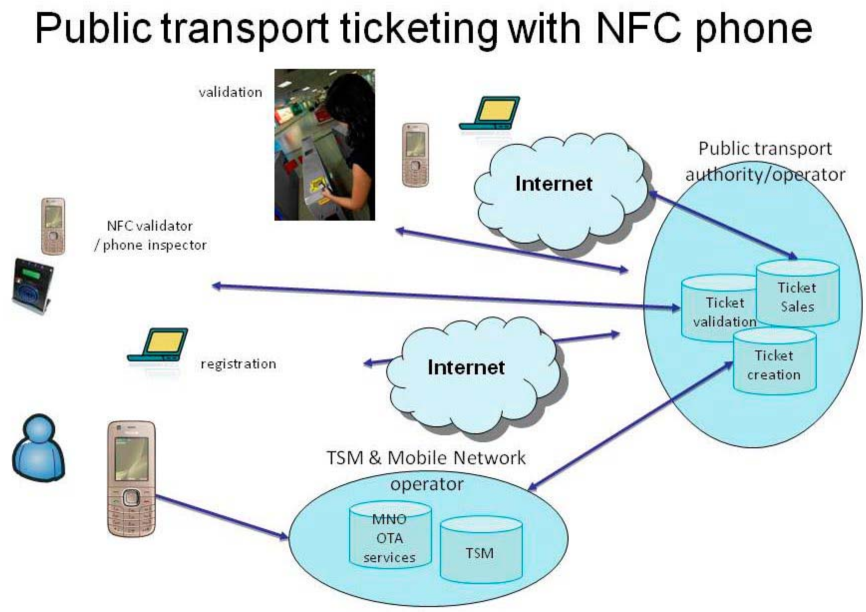

Figure 43. Service architecture for mobile ticketing in public transportation.

The traveller satisfaction is naturally also benefit for the transport operators. NFC-based solutions will also create new revenue opportunities for transport operators from advertisements, promotions and retail purchases taking place in their traffic infrastructure and fleets utilizing NFC. The more fluid traveller flows (thanks to easier ticketing) in check points and reduced operating and maintenance costs have also seen resulting from mobile ticketing.

The currently used contactless cards are already offering partially the benefits described above, but mobile NFC-enabled ticketing allows users to manage multiple tickets (from different stakeholders) in the same time, check the balance of remaining ticket value or ending of the season ticket period, book tickets anywhere etc. See [NFC 2011] for detailed view on the benefits.

ANNEX D – Service impact assessment

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7 Bundle: Electric mobility services

1.1 Description

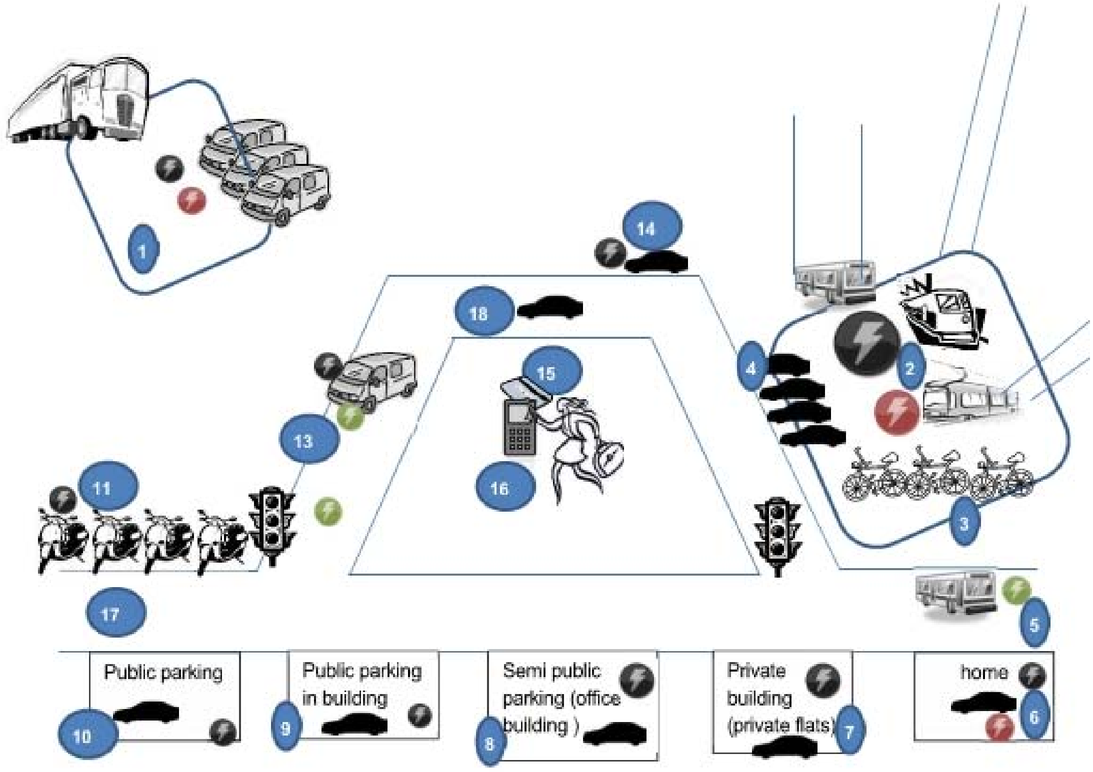

Figure 44: Electric mobility services.

(Source: Pihjalamaa et al. 2012)

1.2 Service: Intelligent charging

1.2.1 Economic impacts

Service: Intelligent charging	Magnitude of impact	Description of the impact
Growth	4	Given the need to shift to alternative sources of energy in the transport sector the future competitiveness of European transport system can be secured by investment to a robust and user-friendly charging system. The growth impact can be significant if the system is advanced in Europe to offset rising fuel prices.
Economic	4	The availability of alternative energy in

Service: Intelligent charging	Magnitude of impact	Description of the impact
competitiveness		transport system in a way that the system describes will improve the competitiveness of Europe significantly.
Economic welfare	4	The welfare impact will be considerable from the European point of view, as the energy self-sufficiency can be increased and dependency decreased (subject to the source of energy, which is assumed to be of European origin and increasingly from renewables).
Investment	4	The system will create major investments by public and private sector, as the investments required will transform current filling stations and even physical infrastructure to meet the needs of the new system.
Market share	5	It is assumed that a number of companies will emerge within Europe to provide the services needed. The expertise gained, if prior to rest of the world adopting similar systems, can be utilised to gain global advantage in provision of services in other regions as well.
Overall impact	4	The service has significant economic potential, which can be fulfilled by early and large-scale introduction in the European markets. This also requires the actions from car manufacturers as the penetration rate of vehicles must reach a critical mass to provide incentives for investments required, in particular from private sector.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.2.2 Social impacts

Service: Intelligent charging	Magnitude of impact	Description of the impact
Cohesion	0	The application does not in particular

Service: Intelligent charging	Magnitude of impact	Description of the impact
		address the social issues. By introducing the intelligent charging the interaction is being reduced.
Health	4	Health impacts, due to reduction of CO2 and other emissions from transport, can be significant. This obviously is pending on the penetration rate of the electric vehicles, but as the described system in its full will require substantial investments it is likely that it will be implemented in a scale that will also lead to considerable health impacts.
Employment	3	The industry created will generate new jobs, which will partially offset some of the jobs at present in traditional service industry. However, as new distribution channels are needed as well as infrastructure construction there is likely to emerge more employment opportunities.
Quality of life	3	The health and employment effects as well as the improved service level are likely to create positive impact on quality of life.
Service level	4	New services are designed to assist the vehicle user to more easily recharge the vehicle. This means an improvement to current charging services and can lead to sustainable improvements in travel within Europe. Hybrid vehicles can increase the range of utilisation of the electric vehicles and also promote more rapid transition to utilisation of electric vehicles.
Greenhouse gas emissions	4	The shift to alternative fuels from fossil fuels will reduce emissions, which will further improve quality of life and leads to health impacts as well. The assumption of European-wide coverage means that the volume of new vehicles is considered great enough to reduce emission as well. As transport sector is the second biggest sector to produce CO2 emission globally and in Europe, and has constantly increased the emission total, a decline of 1/3 of present level of emissions would cancel out the increase observed in the past 20 years.

Service: Intelligent charging	Magnitude of impact	Description of the impact
Overall impact	3 / 4	The service will have a high impact on service level and health, particularly through a reduction in emissions. These factors will improve the quality of life even at the EU level.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.2.3 Policy impacts

Service: Intelligent charging	Magnitude of impact	Description of the impact
More Fluid	0	Intelligent charging systems do not have any impacts on traffic fluency since their main aim is to integrate electro-mobility services with energy ones.
Greener	4	The use of electric vehicles, both private and public, definitely leads to a cut back on greenhouse gas emissions. The potential impact can achieve the European level if a broad coverage of such technologies will be envisaged.
Smarter	4	From the view point of ICT solutions for enabling a smart and integrated environment, the implementation of intelligent charging systems can potentially reach a EU impacts level.
Safer	0	Intelligent charging systems do not have any impacts on the safety of road users.
More Accessible	1	From the view point of EV owners/users, intelligent charging services such as the bi-directional charging in residential buildings can enhance the level of accessibility by making this mobility solution more affordable.

Service: Intelligent charging	Magnitude of impact	Description of the impact
Total impact	4	By looking at the effectiveness of the bundle on each individual policy pillar it must be pointed out that, given the high technical profile of the bundle considered, just three of them can have an impact worth mentioning.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.2.4 Technological impacts

Service: Intelligent charging	Magnitude of impact	Description of the impact
Innovation	4	The technology will significantly improve the availability of alternative energy in the transport sector and can create major innovations in service delivery methods.
Technological breakthrough	4	Provision of services in the new way across Europe will lead to a breakthrough that challenges the traditional energy provision in the sector. Intelligence combined with eco-friendliness can bring along new markets and service providers.
Research competitiveness	5	If executed well, the system can improve the global competitiveness of European transport and energy sector.
Standards agreements	4	Similarly to traditional fuels, the new system must have agreed standards on fuel, as well as the ways in which services will be provided (equipment, payment methods etc.). EU level standards must define how charging is done so that service is available across national boundaries.
Industrial leadership	4	The services needed are likely to be provided by a number of companies, similarly to fossil fuel markets. This means that the market will attract several

Service: Intelligent charging	Magnitude of impact	Description of the impact
		companies that operate across national boundaries and provide services through established brands. A separate issue for consideration is the future role of vehicle manufacturers in the global competition, those which participate in European wide scheme can become global frontrunners, but at present these companies do not necessarily originate from Europe. This will be a point of consideration for industry, both in the European continent and elsewhere.
Technological leadership	5	The service has potential to become global technology leader, if the services are brought to market early and in advance of competitors in other markets.
Integration	4	Technologies from various fields (smart systems, energy, infrastructure etc.) need to be integrated to a holistic system to provide the extensive service proposed. This leads to solutions that are Europe-wide and advance the deployment.
Knowledge transfer	4	Significant knowledge transfer is required in order to generate the new service model that will have European coverage. This includes solutions for various charging options that do not currently exist (at traffic lights, in public parking) and payment solutions (electricity cards etc.).
Infrastructure development	4	Significant developments in infrastructure are foreseen in order to provide the required service level. This increase construction of charging stations both on and off-road as well as construction of charging facilities at domains such as residential and public buildings and at existing filling stations.
Mobility of personnel	3	Due to easier access to services it is likely that more people will take longer journeys using the service that presently has been limited to shorter trips. It needs to be further analysed to which extent the availability of electric vehicles for longer journeys will affect other modes of transport, particularly the use of public

Service: Intelligent charging	Magnitude of impact	Description of the impact
		transport.
Total impact	4	The service has great technological impact and potential for global coverage. Many impacts are pending on the initial investments required and the penetration and coverage of the service provision at the European level.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.3 Service: Electric mobility support services

1.3.1 Economic impacts

Service: Electric mobility support services	Magnitude of impact	Description of the impact
Growth	0	Booking and payment systems for electric vehicle recharging do not have direct growth impacts, although they are part of enabling process of the electric charging to become a major source of energy for the automobile industry.
Economic competitiveness	0	The service does not have economic competitiveness impact as such, but again is linked to impacts of the electric car industry expansion.
Economic welfare	0	There is no impact on economic welfare linked to the supporting services, as the services do not provide as such any change to economy, but are needed to provide the necessary service level to enable the expansion of electric vehicle fleet.
Investment	4	The service will require installation of more smart payment facilities and ICT technology to identify the available parking space and to manage the bookings.

Service: Electric mobility support services	Magnitude of impact	Description of the impact
Market share	5	Payment and booking systems have the potential to become globally used standards and they are most likely to be based on products already offered by multinational service providers.
Overall impact	4 / 5	Economically the main impacts are on the European level and beyond as the utilisation of the services is based on (most likely) existing frameworks used for payment of similar services.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.3.2 Social impacts

Service: Electric mobility support services	Magnitude of impact	Description of the impact
Cohesion	2	Cohesion impacts are created through the booking services which can improve electric vehicles utilisation in the city and regional context. The availability of charging facilities in residential areas and buildings is likely to create more collaboration within these areas among users of the facilities, for instance due to positioning and the related booking of charging facilities.
Health	0	The payment and booking system does not directly produce any health impacts, unlike the actual electric car deployment.
Employment	1	The management of payment and booking systems as well as maintenance of parking facilities with charging opportunities is likely to create new employment but mainly in the limited to city context where service provision will take place.
Quality of life	2	The availability of booking of charging is

Service: Electric mobility support services	Magnitude of impact	Description of the impact
		likely to improve the travellers service within the regional level where most of the activity of regular driving will take place.
Service level	2	Service level improvements are mainly experienced within city and regional traffic where volumes of traffic are greatest and improvements can improve the penetration rate of electric vehicles rapidly.
Greenhouse gas emissions	0	The support functions do not have direct impact on emissions.
Overall impact	2	Social impacts of the service are minor and related to impacts resulting from service level improvement.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.3.3 Policy impacts

Service: Electric mobility support services	Magnitude of impact	Description of the impact
More Fluid	1	For EV users both route guidance and navigation systems integrating the location of charging points can lead to an optimization of the path to be followed. Consequently, there could be a positively impact on the fluency level of road traffic.
Greener	4	Electric mobility support services, such as energy management of buildings integrated with the provision of electricity to the road vehicles and to and from rail vehicles, can reduce GHG emissions thanks to the overall balance of electricity in and out. Therefore, the consequent optimisation of electricity usage can lead to a decrease in primary energy production and then in emissions. Also services like the multimodal trip planning including EV can reduce GHG emissions potentially reaching the EU level, under the hypothesis of a wide adoption of these technologies.
Smarter	2	Integrated electronic payment of all mobility services including electro-mobility ones have a positive impact at city and regional level in terms of making more intelligent the urban transport through ICT applications.
Safer	0	The support functions do not have direct impacts on improvements of urban mobility safety.
More Accessible	1	Information on electro-mobility services in the city integrated within the information on mobility services and energy related information like price, availability and level of battery charging can definitely improve the accessibility of such mobility services at city level.
Total impact	1	By looking at the effectiveness of the bundle on each individual policy pillar it must be pointed out that four out of the five mobility policy dimensions are addressed to the achievements of a sustainable urban system. The span of impacts is inherently confined into the

Service: Electric mobility support services	Magnitude of impact	Description of the impact
		urban dimensions, possibly regional by taking into consideration systematic commuting trips. By promoting the adoption and the deployment of these services to all European urbanized areas, the positive impacts at European scale on the sustainable mobility can be significant.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.3.4 Technological impacts

Service: Electric mobility support services	Magnitude of impact	Description of the impact
Innovation	2	The service requires integration of booking and payment systems and transport system user preferences in a trip-planner, which is integrating the user's preference of transport mode, time of travel, availability of facilities and preferred mode of payment. At least in the beginning, the service providing route planning functions will likely be a regional or member state level route planning service. User needs related to the service and is implementation are likely to be linked with daily travel patterns and are considered to take place in the regional context. (DG-MOVE 2009)
Technological breakthrough	4	The requirements of the system to provide information regarding availability of charging at requested time and place will be considerable. This requires the applicability of the service also across national boundaries and operability through multiple user interfaces, but predominantly through smart phones.
Research competitiveness	3	Most of the integration of information will take place in the national context, through

Service: Electric mobility support services	Magnitude of impact	Description of the impact
		service providers and payment administrating companies. However, these actors can be also multinational and offer similar service to customers in several countries. Increased coverage and use of the service requires the integration of electricity provision from present individual companies service points to multiple service providers operating through the same hub.
Standards agreements	5	Payment standards related to service must be global, whether they are based on credit cards, mobile phones or smart cards.
Industrial leadership	4	Payment leadership will be based on global operators offering of services at the European level, whereas booking solutions are likely to be either European or national level services.
Technological leadership	4	Both payment and booking systems will need to be interoperable at the European level to offer continuity of service.
Integration	4	European level interoperability is needed to ensure continuity of service.
Knowledge transfer	3	Operator(s) of different components of the service will utilise the information and data collected from the service points and users, but mainly within the own organizations and within national context. Predictability of service use will be improved by tailoring services to users according to their travel patterns and behaviour.
Infrastructure development	4	System coverage is Europe-wide and the need to increase the amount of service points will rapidly increase. This will require new electricity connectivity points and services in areas, where presently no services are provided (parking facilities etc.) and to which booking and payment systems should extended.
Mobility of personnel	2	If service is sparsely available people will have to adjust their travel pattern to access the service, if the service is widely available there is no need to adjust the patterns. Most likely the impact in each case will be at regional level, affecting the frequent trips such as commuting traffic.

Service: Electric mobility support services	Magnitude of impact	Description of the impact
Total impact	4	The service has wide-ranging technological impacts that reach the European level impacts. These support services help to improve the use of new services and essential in achieving the goals of greater penetration.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
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4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.4 Service: Urban electric freight

1.4.1 Economic impacts

Service: Urban Electric Freight	Magnitude of impact	Description of the impact
Growth	1	Cities will experience the potential to utilise electric vehicles for freight transport. This is likely to provide some growth in trade and improvement in logistics, but overall impact is likely to remain in the city context.
Economic competitiveness	1	Companies operating within city limits can improve their local operations and gain broader acceptance in partnerships through more green service concept. These impacts are likely to remain location-specific.
Economic welfare	1	Welfare gains are experienced by the companies that receive new business through the service offered. Due to the local context of the service improvement the impacts are also likely to remain city level.
Investment	3	It is likely that major companies that operate at national level or beyond will have the required resources to invest in the technologies required and so the systems are likely to be developed either

Service: Urban Electric Freight	Magnitude of impact	Description of the impact
		by one company for several clients that can utilise the fleet charging systems or some logistics companies that reserve the technology mainly for their own use or rent out services to other companies also adopting same business concept.
Market share	3	Provision of services is likely to national level business and the gains in market share are experienced by the companies that invest in the technology installation, most likely either overall service providers or most advanced logistics companies.
Overall impact	1 / 3	Some of the features of the service are likely to result in national level service providers. However, the economic impacts in terms of growth and welfare remain small and since the service is freight oriented do not address the welfare of individuals.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.4.2 Social impacts

Service: Urban electric freight	Magnitude of impact	Description of the impact
Cohesion	0	The service is mainly directed towards the logistics industry and does not offer any cohesion impacts.
Health	1	Reduction of emissions and less traffic noise from electric vehicles can have minor health impacts at the city level.
Employment	1	Management of service and maintenance are likely to create new employment within the cities where services are focused.
Quality of life	0	There are no major impacts on quality of life as the service is improving the logistics

Service: Urban electric freight	Magnitude of impact	Description of the impact
		industry.
Service level	3	The improvements in provision of electric vehicles freight services in the cities will create a national level system to manage the service and the vehicle fleet. The service level improvement involves both logistics companies and their clients.
Greenhouse gas emissions	1	Removal of current fleet and replacement by electric vehicle fleet is likely to reduce the CO2 emissions within the cities. The urban freight has also regional implications but the actual impacts are considered relatively small so that the impact is restricted to cities where most of the logistics are being operated.
Overall impact	1	Freight-oriented service does not have significant social impacts with the exception of service level improvement. Other impacts are considered minor or non-existent.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
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4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.4.3 Policy impacts

Service: Urban electric freight	Magnitude of impact	Description of the impact
More Fluid	1	Navigation services and booking of loading and unloading areas can improve the efficiency of urban freight transport by optimizing both routes and numbers of daily deliveries and so increasing the fluidity of traffic at city level.
Greener	1	The use of electric vehicles for urban freight deliveries can positively impact the quality of urban environment by reducing CO2 emissions and improving local air quality.
Smarter	2	The integration of the energy management for the urban distribution centres with the provision of electricity to the electric delivery vans by using ICT applications can increase the efficiency of urban freight movements by reaching a regional level in case of metropolitan distribution centres.
Safer	0	There are no major impacts on safety due to services improving the logistics industry.
More Accessible	1	From the view point of urban freight delivery users the implementation of freight EV can lead to an increase in accessibility to city center because of different level of constraints to the access restricted zones.
Total impact	1	Except for safety which is not influenced by urban electric freight services, the other four mobility policy dimensions are addressed to the achievements of a sustainable urban system. The span of impacts is inherently confined into the urban dimensions, possibly regional by taking into consideration systematic commuting trips. By promoting the adoption and the deployment of these services to all European urbanized areas, the positive impacts at European scale on the sustainable mobility can be significant.

Legend:

0 = no impact

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3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.4.4 Technological impacts

Service: Urban Electric freight	Magnitude of impact	Description of the impact
Innovation	3	The innovation is mainly linked to overall infrastructure provision for electric vehicles. Most likely the innovation is likely to emerge in the national context, where the operations can be administrated in a new way based on the technologies provided.
Technological breakthrough	3	The ecosystem for electric urban freight will mainly operate within cities but based on national level service provision as described in the economic impacts.
Research competitiveness	1	Most likely the technologies in general follow those of personal vehicles, but within cities the availability of space for charging may lead to new research and innovation for location of services.
Standards agreements	3	Standards on operating the system need to be enforced at national level (minimum requirement). Potential for EU level agreements exists.
Industrial leadership	3	Most likely a national level leadership is provided by a company that manages the service provision. Potential for EU level leadership exists if the business becomes attractive.
Technological leadership	3	Leadership is linked to service provision, in the national context there is likely to be one or maximum a handful of companies that can provide specialized services for freight given the size of the market.
Integration	3	Logistics sector needs and electric vehicle technologies need to be integrated to provide a robust system at the national level.
Knowledge transfer	3	Sharing the information regarding the logistics industry needs and providing technology solutions that make the use of

Service: Urban Electric freight	Magnitude of impact	Description of the impact
		electric freight vehicles more common requires an intense dialogue in generating a service model. This information will complement the services for other vehicles but also take into consideration the day-to-day operations of logistics companies.
Infrastructure development	3	New infrastructure will be required to provide the charging to vehicles in new locations.
Mobility of personnel	0	The service does not have mobility impacts as it does not reduce amount of freight vehicles nor it is addressing passenger transport.
Total impact	3	Major technological impacts are expected to take place at the national level so that services can be provided to freight and logistics companies, particularly when connected with loading and off-loading of cargo while charging the vehicles.

Legend:

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8 Bundle: Multimodal mobility services

1.5 Service: Social traffic

1.5.1 Description

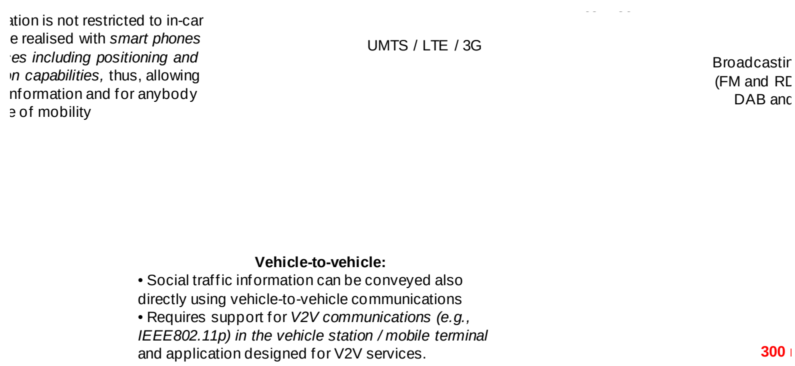

Figure 45: Social traffic.

(Source: Pihjalamaa et al. 2012)

1.5.2 Economic impacts

Service: Social traffic	Magnitude of impact	Description of the impact
Growth	1	The application is likely to have impacts through improved efficiency of the transport system but such impacts are minor and likely to take place at the city level.
Economic competitiveness	1	The impacts, as with growth, are likely to remain small and within local context. Competitiveness improvements again result from efficiency gains.
Economic welfare	2	Welfare effects will come from reduced travel time both for society and individuals.

Service: Social traffic	Magnitude of impact	Description of the impact
		However, the effect will be limited in magnitude and not extending beyond the regional level
Investment	1	The application does not require any significant investments apart from data storage facilities. However, if the data will be linked to authorities data in terms of emergencies there may be need to provide additional data management services.
Market share	3	Most likely a single company will develop an application that can be used within a country, possibly a European wide provider will emerge if the business model turns out to be profitable.
Overall impact	1	The service is not economically interesting but can have major social potential.

Legend:

0 = no impact
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4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.5.3 Social impacts

Service: Social traffic	Magnitude of impact	Description of the impact
Cohesion	4	The social applications are able to create significant impacts on social cohesion that can bring about European level use of the media applications. Attractiveness, usefulness of information and the interfaces with existing social media applications will determine the full impact created by the total volume of users. The easiness to use new mobile applications, when connected to already existing technologies can be a good driver for broad use of services.
Health	1	The health impacts within city level will be results of aiding use of light traffic and also potentially due to less accidents, for

Service: Social traffic	Magnitude of impact	Description of the impact
		instance through better information on potential threats and obstacles along routes.
Employment	1	The locally produced content and the management of data will create some new employment opportunities, but in general due to the nature of the business (technology-driven, automated services) opportunities remain limited.
Quality of life	4	Increased opportunities created by social media can lead to improvements in quality of life at the European level. This is based on more easy communication methods and satisfaction derived from interaction and information received.
Service level	2	Services generated will add value the city/regional level, due to the local nature of use of data provided by the social traffic application. Compared to earlier situation, the new service level can be considerably greater, but mainly in the local context. Naturally the availability of the application across Europe will give similar benefits when people move from one city to another. By verifying user information and profiles the system can create reliable up-to-date location-specific travel information.
Greenhouse gas emissions	1	Efficiency of traffic system will increase and leads to less emissions, similarly the ability of the application to promote use of public transport and light traffic can also lead to reduction in emissions; however, the volume is likely to remain small, justifying the assessment of minor, city level impact.
Overall impact	1	Social impacts are mixed, but some potentially reach the EU level. The key question is to what extent the service can introduce new people to utilise social media and how the society as a whole will benefit from this.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level

3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.5.4 Policy impacts

Service: Social traffic	Magnitude of impact	Description of the impact
More Fluid	2	As mobile devices and dashboard services become increasingly intertwined, drivers are now able to communicate traffic and road conditions back to the cloud to be interpreted, verified and distributed to a network of equipped drivers. This can allow a better use of the road network and consequently a more flowing traffic at local and regional level.
Greener	1	The enhancement of navigation services and the provision of suggestions on better routes to take in order to avoid traffic and reach the destination can lead to a decrease in traffic congestion and, as a consequence, to a better air quality at local level.
Smarter	4	Commercial ITS services using a crowdsourcing methodology can help in solving a very trying problem as a community of drivers uses their mobile phones or in-vehicle devices to warn other drivers about traffic holdups in a particular area. By implementing such services using standard interfaces a minimum degree of interoperability of ITS applications in towns and cities can be assured and a potential EU level impact can be achieved.
Safer	2	Social traffic services can contribute to increase the safety levels in cities by providing rapid and appropriate information. Intelligent on-board systems, for instance, can recognize incidents automatically from anomalous measurements such as strong deceleration, and proactively forward confirmed information to right responsible parties.
More Accessible	2	Solutions conveying the crowd sourced traffic data to traffic information centres

Service: Social traffic	Magnitude of impact	Description of the impact
		can ensure that important information reaches a wide group of people. This can then improve the quality of access that people and business have to the urban mobility system.
Overall impact	2	The five mobility policy dimensions are addressed to the achievements of a sustainable urban system. The span of impacts is inherently confined into the urban dimensions, possibly regional by taking into consideration systematic commuting trips. By looking at the effectiveness of the bundle on each individual policy pillar it must be pointed out that all of them are positively affected by the delivery of the services; therefore, by promoting the adoption and the deployment of these services to all European urbanized areas, the positive impacts at European scale on the sustainable mobility can be very high.

Legend:

0 = no impact
1 = potential impact, within the city limit
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4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.5.5 Technological impacts

Service: Social traffic	Magnitude of impact	Description of the impact
Innovation	4	European level connectivity increases, will link new areas of social media applications to mainstream media. Innovation is within the new content, not on technology side.
Technological breakthrough	3	Will require data integration, including cloud service and user interface (hardware/software) infrastructure development, mainly focusing on integration of new and existing data and services to a new service package.
Research competitiveness	3	Most likely to generate within countries expertise to generate solutions that fit local language/culture/infrastructure, will lead to innovations in cost-effectiveness of service provision.
Standards agreements	4/0	In the case that the service will be integrated to or working in parallel with official data systems such as RDS TMC or eCall, the operation of data within the system will require agreement on the principles of data usage, including the reliability and responsibility of data quality. These principles should be EU level as the official systems will need to function across country borders. In the case that the system will be based on private sector led commercial application only, no standards are required.
Industrial leadership	3	It is likely that at country level the service provision will be done by a single company, which will have national leadership. If provided by global company the application could be world-wide as well.
Technological leadership	1	Major technological demands are not foreseen and the leadership will be limited to city level solutions. Most likely the companies specialized in data warehouse services can benefit from their expertise and provide supplementary services to service integrators.
Integration	4	Assuming Europe-wide coverage, applications will have European level integration impacts through social media coverage of the region. Using common social

Service: Social traffic	Magnitude of impact	Description of the impact
		media apps the integration will be greater and can bring new users to existing social media.
Knowledge transfer	2	Knowledge transfer, mainly related to the transfer of content, within the application(s) takes place within the city/regional level.
Infrastructure development	2	The minimum requirements of the system for ICT infrastructure are the availability of 2G/3G network suitable for data transmission, back-office systems provided by a service provider and availability of mobile terminals and in-vehicle systems capable of two-way data transmission. Most of the current car navigators receive traffic information via broadcast technologies but are not connected to 2G, 3G or any other mobile network.
Mobility of personnel	2	Due to better data availability commuting traffic can benefit from the social traffic application, also potentially increasing the use of public transport and light traffic.
Total impact	2 / 3 / 4	Main technological impacts will be observed at city/national level. It is likely that technological breakthrough will be needed at the national level and it can serve as further integrator between social media and traditional traffic information applications.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.6 Service: Dynamic car sharing

1.6.1 Description

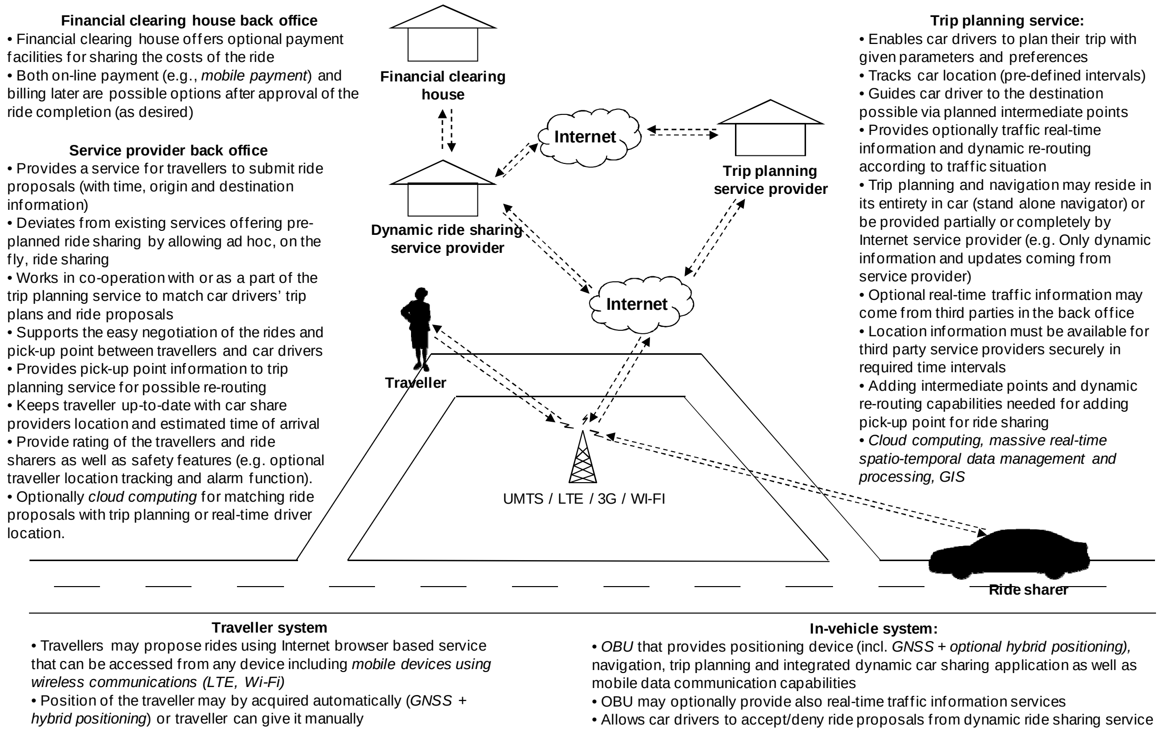

Figure 46: Dynamic car sharing.

(Source: Pihjalamaa et al. 2012)

This service will only be available in the countries, where transporting passengers in exchange for payment of services is not regulated by permits to provide such services. The service can be seen to compete with other service providers (taxis and buses) and thus violating the regulations.

1.6.2 Economic impacts

Service: Dynamic car sharing	Magnitude of impact	Description of the impact
Growth	1	Depending on the penetration rate of the application, the car sharing can reduce volume of cars on roads and congestion. This will lead to time savings, which improve productivity and generate growth effects. However, these will be of magnitude observed at the city level as the accumulated time savings will not create European level impacts.

Economic competitiveness	1	The magnitude of impacts does not impact economic competitiveness beyond the dynamics of a city.
Economic welfare	1	From society's point of view the impacts will remain small and can in principle be observed at city level.
Investment	1	Not expected to generate major investments outside the standard city level technologies, which will utilise to some extent the existing infrastructure.
Market share	3	Most likely a single company will develop an application that can be used within a country, possibly a European wide provider will emerge if the business model turns out to be profitable.
Overall impact	1	The service is not economically interesting but can have major social potential.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.6.3 Social impacts

Service: Dynamic car sharing	**Magnitude of impact**	**Description of the impact**
Cohesion	2	Cohesion impacts can be created by linking supply and demand of commuting travellers. As the impacts can also be observed within a regional commuting pattern (either due to longer route commuters using car sharing or due to less congestion in inner city traffic) the cohesion of commuters can be enhanced beyond city limits.
Health	1	No major health effects will be observed, potentially small impact for those increasing their exercise as part of taking part in the car sharing.
Employment	1	Only the provision of services will generate new employment, no catalyst effect is

Service: Dynamic car sharing	Magnitude of impact	Description of the impact
		expected.
Quality of life	1	Within cities the reduction of traffic and availability of better connectivity through car sharing can improve quality of life but these impacts do not go beyond the immediate surroundings.
Service level	1	New services available can improve a city's attractiveness to commuters and other users of the dynamic car sharing system. However, the improved service can be experienced only within a city implementing the service concept.
Greenhouse gas emissions	2	Reductions within a city that operates a dynamic car sharing system can lead to regional impacts due to reduced emission as a result of less commuting vehicles.
Overall impact	1	Overall social impact remains at city and regional level due to the nature of the service.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.6.4 Policy impacts

Service: Dynamic car sharing	Magnitude of impact	Description of the impact
More Fluid	1	A dynamic car sharing system can improve the urban traffic fluidity by allowing an 'on the fly' ride sharing working in cooperation with a trip planning service to optimise pick-up points and travel distances, together with the provision of a re-routing option.
Greener	1	Sharing vehicles in urban areas can reduce the number of cars and, additionally, having a dynamic re-routing according to traffic situation can reach an even better urban environment in terms of less polluted air.
Smarter	4	ICT based solutions are fundamental in a demand-driven vehicle-sharing arrangement to guarantee the screening of participants (both owners and renters) and technical solutions bringing different parties together, managing rental bookings and collecting payments. Additionally, an automated form of insurance and breakdown coverage can be applied to rentals that take place through the service in order to protect an owner's existing insurance coverage.
Safer	2	Dynamic ridesharing can raise safety and security perceived levels by having all users register with the ride-matching service provider, or the sponsoring organization, before arranging rides. These services can also have the option to let users setting their own criteria for rideshare partners (e.g. some women wanted to ride only with other women)., pickup locations, how long to wait, and the like to enhance their own comfort.
More Accessible	1	Dynamic ridesharing is considerably more flexible than traditional ridesharing arrangements and this can be translated into a more accessible service. It allows in fact travellers to offer or request a ride just minutes before their desired departure time or to make scheduled appointments for one-time, one-way trips. This flexibility

Service: Dynamic car sharing	Magnitude of impact	Description of the impact
		eliminates the need to commit in advance to a fixed commute schedule or to commit to travel with particular individuals on an on-going basis. The service also covers geographical areas where public transport operates has less frequent or no connections and times when public transport operates less frequently or not at all.
Overall impact	1	The five mobility policy dimensions are addressed to the achievements of a sustainable urban system. The span of impacts is inherently confined into the urban dimensions, possibly regional by taking into consideration systematic commuting trips. By looking at the effectiveness of the bundle on each individual policy pillar it must be pointed out that all of them are positively affected by the delivery of the services; therefore, by promoting the adoption and the deployment of these services to all European urbanized areas, the positive impacts at European scale on the sustainable mobility can be high.

Legend:

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5 = potential impact, reaching global level

1.6.5 Technological impacts

Service: Dynamic car sharing	Magnitude of impact	Description of the impact
Innovation	2	The innovation in technology will have regional dimensions, which make commuting/leisure traffic operate more smoothly.
Technological breakthrough	3	At the city level, the availability of the dynamic car sharing will result in new solutions for transport system users, but the

Service: Dynamic car sharing	Magnitude of impact	Description of the impact
		more common use will be within national boundaries as this service can increase the amount of shared rides.
Research competitiveness	3	Competition on the service provision may emerge within national boundaries but it is likely that due to the fairly limited market for the service only one service provider will remain, based on the most user- and cost-friendly solution.
Standards agreements	0	No standards are required for this type of service.
Industrial leadership	3	It is likely that a national level service provider will emerge and due to the nature of the service one service provider is likely to cover a national market.
Technological leadership	3	Most likely the national level service provider, or integrator, is likely to provide leadership at the national level.
Integration	0	The service is a single application, which does not require technology integration.
Knowledge transfer	0	No knowledge transfer is required in the system.
Infrastructure development	0	No infrastructure development is required.
Mobility of personnel	3	Mobility impacts can be observed at the national level, giving people who do not own a vehicle opportunities to travel according their travel needs.
Total impact	3	The technology impact is seen at national context. With the assumption of the market size it is plausible that within national boundaries a single service provider will emerge contributing to industry leadership at this level. However, technology needs and market potential are small for this service.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
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5 = potential impact, reaching global level

1.7 Service: Personal travel companion

1.7.1 Description

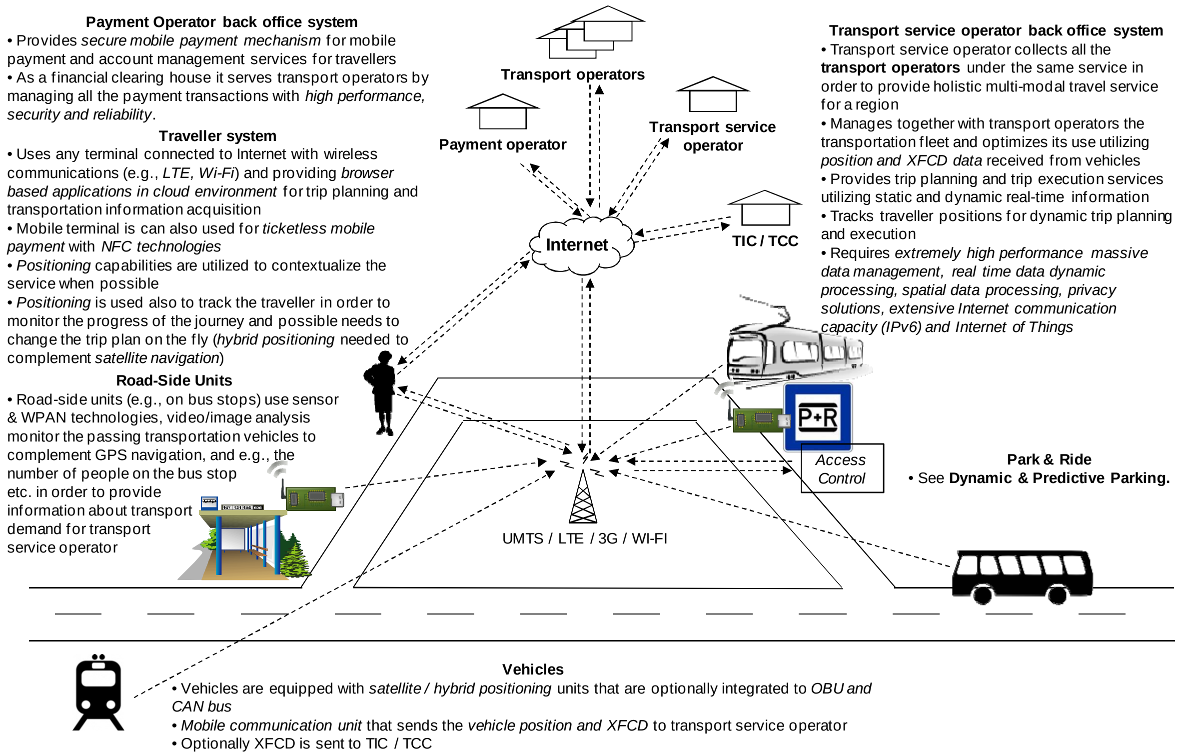

Figure 47: Personal travel companion.

(Source: Pihjalamaa et al. 2012)

1.7.2 Economic impacts

Service: Personal traffic companion	**Magnitude of impact**	**Description of the impact**
Growth	4	There are likely be growth impacts within a city that adopts the personal traffic companion service. These impacts are based on the time savings by travellers from improved route choice and better information of the travel opportunities. This impact can be expected to be similar to impacts of public transport route planners providing similar functionalities (Laine, Pesonen, Moilanen 2003).
Economic competitiveness	2	The size of the growth impacts will most likely be small in national scale so the competitiveness of a city which adopts the

Service: Personal traffic companion	Magnitude of impact	Description of the impact
		service can increase but these impacts do not scale up to regional or national level magnitude.
Economic welfare	2	Welfare gains from improved traveller information and a seamless payment system will be realised in the urban areas where the service is provided. The impacts will depend on transport modes available and covered by service. Socio-economic benefits of the service will be realised at city or regional level.
Investment	1	The services offered will require investments in major data management system, but as the applications will be run at city level, the investment even if done by a national level service provider is considered to affect the city level most.
Market share	4	Due to the investment needed in data management it is likely that at national level a single service provider will emerge.
Overall impact	2 / 4	Most of the impacts associated with the service are of European level, but as there are no major investments associated the overall impact remains slightly below the European coverage. However, the economic impact is one of the biggest among all services evaluated in this report.

Legend:

0 = no impact
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2 = potential impact, reaching regional level
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4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.7.3 Social impacts

Service: Personal traffic companion	Magnitude of impact	Description of the impact
Cohesion	1	The service supports the goal to increase the share of public transport in cities. It also improves the mobility of travellers having no access to a private car. The service likely has a positive impact on social

Service: Personal traffic companion	Magnitude of impact	Description of the impact
		cohesion but this effect will be realised at city level.
Health	1	Health impacts will result from more opportunities to utilise public transport effectively and the associated use of light traffic, however again due to the nature of the service these impacts are likely to remain at city level.
Employment	1	Employment impacts are related to the service set up, no major additional employment impact is foreseen. The data management and interface design will require additional staff resources from the service provider(s).
Quality of life	4	At the European level, the quality of life is likely to increase due to the better information availability on the transport system. This will boost the use of public transport and lead to less congestion.
Service level	4	The service level experienced by users of the transport system will increase and the opportunities to assist tourists and visitors will improve the service provision from the EU point of view.
Greenhouse gas emissions	1	Reductions or slower growth in emissions will result from increased use of public transport, however the impacts of the service are likely to remain on city or regional level. Advanced and easy to use information services will be a part of the package of measures required to increase the share of public transport in European cities.
Overall impact	1	The social impact is a mix of city level developments and Europe-wide processes result from service level and quality of life improvements.

Legend:

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5 = potential impact, reaching global level

1.7.4 Policy impacts

Service: Personal traffic companion	Magnitude of impact	Description of the impact
More Fluid	1	Personal travel companion services by providing information on the progress of the journey also re-planning trips because of unanticipated events in transportation or change of traveller's plans can lead to a better urban traffic management due to shorter journey times. There is also potential to reduce congestion if the share of public transport of all motorised trips could be increased.
Greener	1	Personal travel companion services can make public transport more attractive and, therefore, increase the use of collective transportation means which will induce a local emissions abatement.
Smarter	4	Personal travel companion services through the capabilities provided by the future Internet technologies can give multi-modal travel assistance to users, mainly in urban and inter-urban areas. The services can be addressed to travellers for helping them to plan and adjust in real time a multi-modal journey from door to door; to vehicle drivers for allowing them, for instance, to easily book a parking place or have information about access control in a certain area; to transport operators for providing them with the complete information necessary to initiate demand-driven transportation.
Safer	2	Traveller positioning in fact allows effective localization of any unsafe situation the user can happen to be. The service also allows promotion of safer routes and transport modes. Impacts on the safety and security of travellers are likely to be limited and remain at city or regional level.

Service: Personal traffic companion	**Magnitude of impact**	**Description of the impact**
More Accessible	2	Personal travel companion services can allow a better accessibility to transport services by easing the way to plan a trip, namely by taking into consideration traveller's context and preferences, city rules, current requirements and constrains.
Overall impact	1 / 2	The five mobility policy dimensions are addressed to the achievements of a sustainable urban system. The span of impacts is inherently confined into the urban dimensions, possibly regional by taking into consideration systematic commuting trips. By looking at the effectiveness of the bundle on each individual policy pillar it must be pointed out that all of them are positively affected by the delivery of the services; therefore, by promoting the adoption and the deployment of these services to all European urbanized areas, the positive impacts at European scale on the sustainable mobility can be high.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.7.5 Technological impacts

Service: Personal traffic companion	**Magnitude of impact**	**Description of the impact**
Innovation	4	The fact that the service can become Europe-wide available can have innovation potential that spread across all countries where the service is provided. Benefits will be also extended to those who can utilise the service when visiting these countries. Innovation remains in offering passengers at the European level better real-time travel information in a user-friendly way.
Technological breakthrough	3	Except for the data management, there is no major technology advancement envisaged so the impact will be mainly at the city level. Integration will be needed and interfaces for data usage will be needed.
Research competitiveness	3	The service will mostly be based on existing technologies and standards. The deployment of the service will start at city or regional level. Solution providers will most likely compete at national or European level.
Standards agreements	4	In order for the service to become commercially attractive, an interface that can accommodate the systems from various cities and countries would lead to both data format standards and standardized interface design, which would require an agreement on the standard of information provision.
Industrial leadership	4	The development of the service can be expected to follow a pattern which has been experienced with multimodal route planning services. It is likely that regional or national level service providers emerge first and that European level or global stakeholders enter the market after that. For example, Nokia provides multimodal route planning (Nokia Transit) as a service bundled with the

Service: Personal traffic companion	Magnitude of impact	Description of the impact
		smartphone, and Google has its own service Google Transit. At present, multimodal route planning is provided by different stakeholders and on the basis of several different business models (Rapp et al. 2011).
Technological leadership	3	It is assumed that a national level service provider will emerge to ensure the interoperability of the user interface between cities so that the benefits will take place not only in the immediate city context but also during travel to other cities which operate with same system.
Integration	4	Systems integration at the EU level is needed to ensure the broad user base. This integration can be enhanced by use of multiple media (phones, internet etc.) for data provision and user-friendly pricing and interface solutions, including roaming costs.
Knowledge transfer	1	Knowledge transfer is related to the set-up of the system as various stakeholders need to jointly agree on the principles and format of data provision to make the system work.
Infrastructure development	1	Apart from the data management system and user interface, no major investments in basic infrastructure are envisaged.
Mobility of personnel	4	The impact should be considered EU-level, if the interface to various national and city level systems becomes standardized across the Europe.
Total impact	4	The service has major impacts on utilisation of existing technologies and potential to become a truly European level of service.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.8 Service: Incentive-based traffic optimization

1.8.1 Description

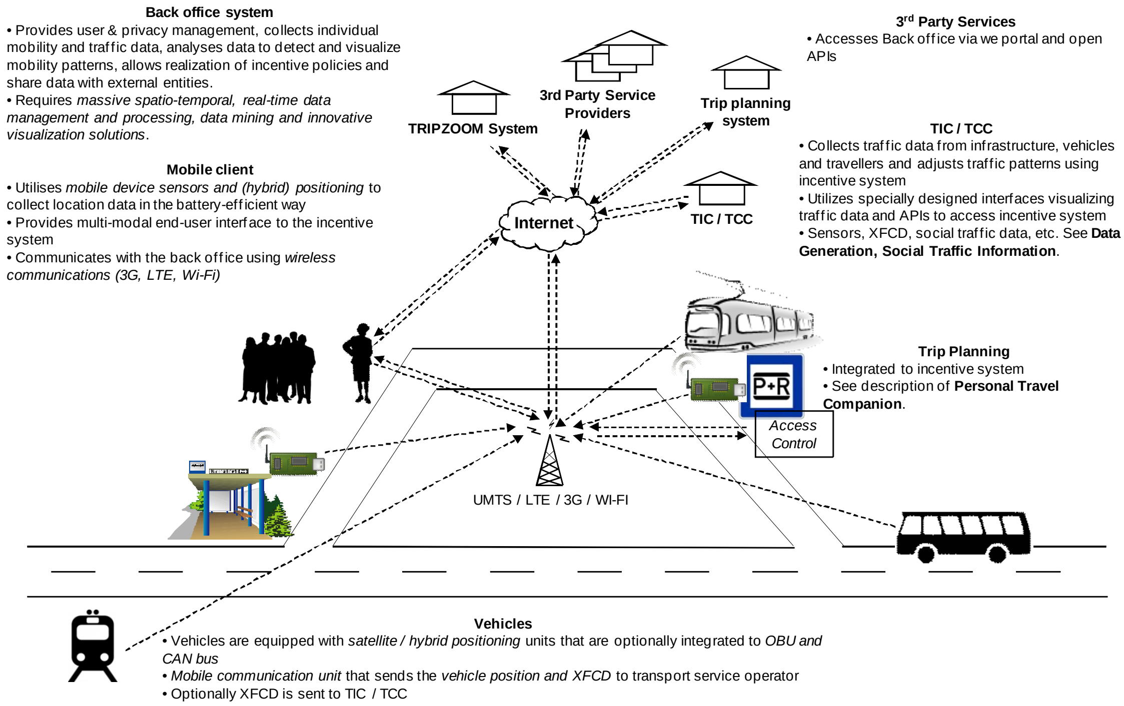

Figure 48: Incentive-based Traffic Optimization.

(Source: Pihjalamaa et al. 2012)

1.8.2 Economic impacts

Service: Incentive-based traffic optimization	**Magnitude of impact**	**Description of the impact**
Growth	1	The traffic optimization can lead to time savings for travellers, which can be significant from a city point of view. However, it is difficult to imagine these impacts to take place beyond a city limit in any case.
Economic competitiveness	1	The service will have limited impact on economic competitiveness within the immediate surroundings, a city level. This is due to the nature of the service in terms of the overall economic impact.
Economic welfare	1	People using the system can take advantage of the time savings and improved travel data available, but again due to the limited scope of the service (individual passengers) the welfare impact is considered to take place within limited

Service: Incentive-based traffic optimization	Magnitude of impact	Description of the impact
		geographical context.
Investment	3	Massive data storage and management is required with rapid processing of data. This calls for large-scale data storage facilities that are likely to emerge at the national level. Investment is most likely done by one major service provider within national context.
Market share	3	As the requirements for data storage and management are great, it is likely that a single enterprise will manage the system within national boundaries.
Overall impact	1 / 3	Economic impacts are not considered great due to the nature of the service. Most impacts are observed within cities in terms of mobility of people and the national context where investments are needed.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.8.3 Social impacts

Service: Incentive-based traffic optimization	Magnitude of impact	Description of the impact
Cohesion	2	The application will improve the availability of travel information in a way that can be utilised at city and regional level improving cohesion by providing greater access to transport system for those that can use the applications.
Health	1	Health impact can be observed if people utilise public transport as a consequence of the new service and combine that with more use of light traffic.
Employment	1	Some new jobs will be created for data management and the maintenance of the service but the overall employment increase will be modest.
Quality of life	3	Service will improve the quality of life through better availability of travel information that can also ease the trip planning process.
Service level	3	Due to availability of multimodal travel information for travellers the passengers can enjoy greater degree of freedom in their travel planning and can receive information in new format that can better combine changes in transport system with pre-planned trips.
Greenhouse gas emissions	1	The system can improve the efficiency of transport system use and promote the use of public transport but these impacts are likely to take place only at city level.
Overall impact	1 / 3	The major social impact of this service is through the improved service but since the focus in on social media applications it is possible that social cohesion is also improving. Other impacts remain at city level.

Legend:

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3 = potential impact, reaching national level

4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.8.4 Policy impacts

Service: Incentive-based traffic optimization	**Magnitude of impact**	**Description of the impact**
More Fluid	1	Through a dynamic creation and management of incentive policies encouraging an optimized traffic by rewarding those travelers who change their traffic behavior according to these policies, the fluency of traffic in cities can be improved. Impacts on fluency of traffic can be realized through changes in transport mode, departure time or route choice.
Greener	1	Thanks to services like the definition of a set of rules that users have to fulfil and a reward that they can earn – e.g., take the bike instead of the car to get a coupon financed by a bicycle store – the quality of urban environment will improve by decreasing the use of not sustainable transport modes.
Smarter	1	Incentive-based traffic optimisation services, such as personal mobility sensing, make use various ICT systems. These technologies are used for example to track how citizens make use of the network, by detecting or deducing the so-called '4 Ws' of personal mobility (i.e. when do people move, where (via which route), with whom, and using which modality). For this reason the urban level of smartness will be increased.
Safer	1	Services such as the personal mobility sensing which identifies and localizes any unsafe situation citizens can encounter will increase the safety level in the urban context.
More Accessible	1	Incentive-based traffic optimization services can increase the quality of access that people have to the urban mobility system. They in fact allow citizens to share their personal mobility patterns by using a platform not requiring a specific network and so simplifying the integration with

Service: Incentive-based traffic optimization	Magnitude of impact	Description of the impact
		other functionality that the portal and mobile applications offer.
Total impact	1	The five mobility policy dimensions are addressed to the achievements of a sustainable urban system. The span of impacts is inherently confined into the urban dimensions, possibly regional by taking into consideration systematic commuting trips.

Legend:

0 = no impact
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4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.8.5 Technological impacts

Service: Incentive-based traffic optimization	Magnitude of impact	Description of the impact
Innovation	2	The application will support normal day-to-day movement of people, which usually takes place in a limited city/regional context. The service does not have major innovation impact beyond this geographically limited area. The application has potential to reach the European level impact, but this may take considerable time.
Technological breakthrough	3	Setting up the service at national level will require integration of various data sources and incentive schemes and maintenance of massive database. These services can be considered new and require critical mass of users, which can take place only at national level and above.
Research competitiveness	3	Integration of existing sub-services into operational service offered to customers requires the coordination of best available methods at the implementation, e.g., the national, level.
Standards agreements	4	The data security and user privacy standards

Service: Incentive-based traffic optimization	Magnitude of impact	Description of the impact
		have to be set and access to data for various stakeholders has to be defined without compromising the privacy of individual system users.
Industrial leadership	3	The service will require significant investments into management of the data and creating a well-functioning user interface, which result in a single service provider within a country (and possibly no service is smaller Member States where the data service provision would be too costly due to limited volume of service users).
Technological leadership	3	One national level service provider (which can also offer services to other countries, including the smaller countries with same language, for instance) is likely to emerge and to offer the service within a country context. This is because of language and systems integration requirements that are easy to achieve within the country rather than across Europe.
Integration	3	Service provision is assumed to take place at national level, however if the service turns out to be successful and to offer major business opportunities across Europe the national provider(s) can expand the service across national boundaries.
Knowledge transfer	3	The concept is universal, however due to the assumed national context of implementation the knowledge transfer will also take place mainly within the same geographical location. In the case several similar services emerge in different countries some of the technology solutions can be transferred from one country to another.
Infrastructure development	2	In-vehicle positioning units providing real-time data and related data collection and management infrastructure will be required to implement the service. This will require investments within the city and regional context.
Mobility of personnel	3	The system will improve travel patterns of people and integration of use of public transport to daily routines in more efficient

Service: Incentive-based traffic optimization	Magnitude of impact	Description of the impact
		way. However, most incentives to work require sufficient weight or end up providing rewards to those already using the rewarded systems.
Total impact	3	There are great expectations that the service would reach at least national level use in general terms across Member States. Most of the impacts are therefore assumed to take place at this level. As there are individuals' travel patterns concerned in the service there needs to be some standards regarding data access and use by service providers and authorities. Most likely such standards will emerge at European level.

Legend:

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5 = potential impact, reaching global level

9 Bundle: Urban logistics services

1.9 Service: Eco-driving

1.9.1 Description

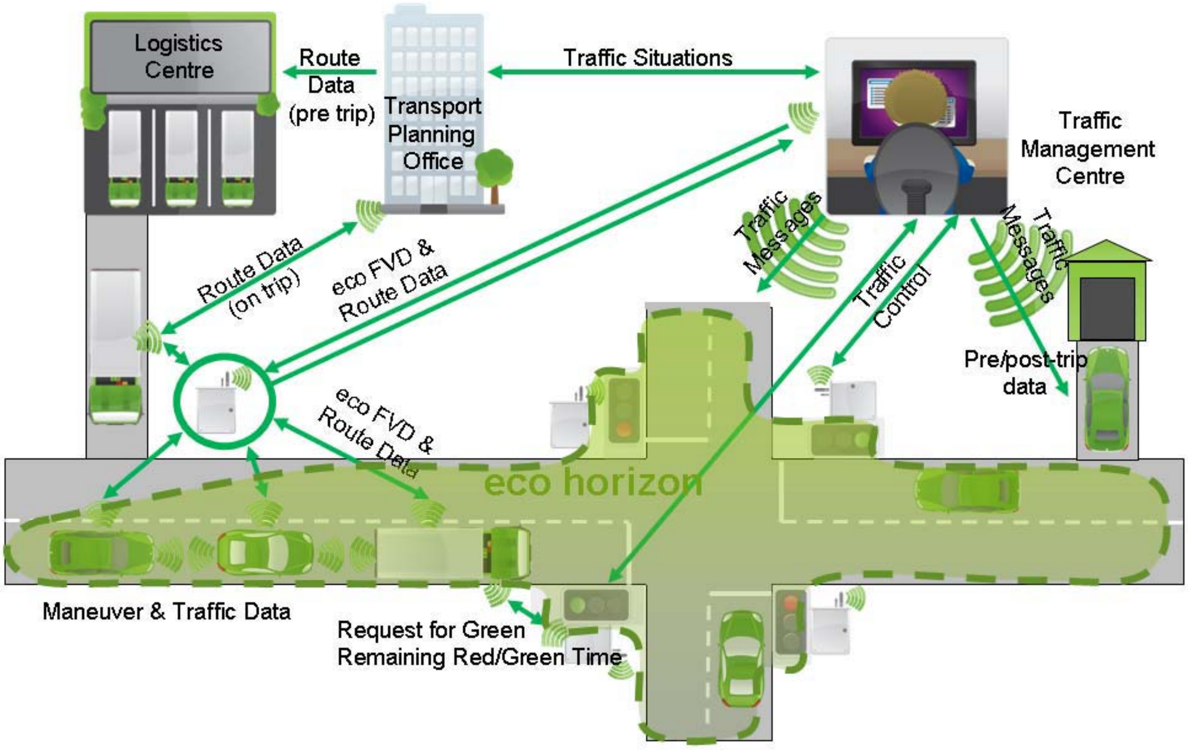

Figure 49: Eco-driving concept.

(Source: Pihjalamaa et al. 2012)

1.9.2 Economic impacts

Service: Eco-driving	Magnitude of impact	Description of the impact
Growth	4	The optimization of travel routes for freight and the associated fuel savings can generate growth through greater efficiency of the logistics chain. These will improve Europe's industries operations and provide opportunities to gain advantage over regions where such service is not available.
Economic competitiveness	5	The targeted reduction in fuel consumption and the greening of transport can give Europe a competitive edge with respect to rest of the world. The impact can be

Service: Eco-driving	Magnitude of impact	Description of the impact
		significant in terms of reduction of required energy imports.
Economic welfare	5	The welfare gains from the service will be globally significant provided that the implementation becomes broad and European coverage.
Investment	4	Massive investments will be needed in in – vehicle systems, data storage and processing, as the system will require integration of various types of data, including user profiles and preferences.
Market share	4	Implementation of the service requires cooperation of public and private stakeholders. While roadside systems will be provided by the road operator and certain back-office systems by public sector stakeholders, the in-vehicle system is on the responsibility of the operator of the vehicle. The system has potentially an impact on the market shares of companies providing IEEE802.11p roadside units and traffic control systems as the manufacturers supporting the service will get an advantage over their competitors.
Overall impact	4	The potential of this service is both Europe-wide and beyond. Most of the expectations are based on the assumption data use and availability is Europe-wide and will endorse more users to utilise the service. Critical factors are both coverage of sufficient amount of cities and the amount of users of the service.

Legend:

0 = no impact
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2 = potential impact, reaching regional level
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4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.9.3 Social impacts

Service: Eco-driving	Magnitude of impact	Description of the impact
Cohesion	1	The service will have limited cohesion impact, which is created by the use of the service by different user groups.
Health	1	The use of less energy and fuel will lead to reduction in greenhouse gas emissions, which will have improvements in health at least at the city level.
Employment	1	The system will require maintenance and user assistance staff, which is mainly required at the city level.
Quality of life	2	The system will likely reduce emissions and noise in cities and thus improve the quality of life. However, this impact will be realised at city or regional level.
Service level	3	The system will provide new functionalities such as enhanced information on most fuel efficient route and energy efficient traffic control functions which are not provided by current eco-driving applications. These impacts will be realised on national level.
Greenhouse gas emissions	4	Europe 2020 strategy has a target of reduction of 20 per cent of emissions will lead to significant improvement in emission levels. Achieving this would be a major contribution of transport sector to fighting climate change.
Overall impact	1	Major social impacts will be achieved through the improvements in quality of life and service level. As the service is intended to reduce the emissions of transport system the additional European level impacts will result from the reduced emissions, which, if the service becomes Europe-wide, will be significant.

Legend:

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5 = potential impact, reaching global level

1.9.4 Policy impacts

Service: Eco-driving	Magnitude of impact	Description of the impact
More Fluid	1	Most eco-driving services such as trip planning in most energy efficient way, navigation via most fuel-efficient route will have a positive impact on fluency of traffic in cities. Impacts of driving support recommending the most energy efficient way to drive on traffic fluency are likely to be mixed (Klunder et al. 2009, Qian and Chung 2011).
Greener	2	Eco-driving services aim at supporting drivers to drive in a more energy efficient manner. They consent, for example, to exchange data describing drivers' current state. In this way the vehicle (and its driver) and the traffic system can each benefit from extra information that allows them to perform better and reduce their energy consumption. For this reason there will be a considerably impact at city and regional level.
Smarter	2	Eco-driving services will have a regional impact in terms of enhancement of ITS applications by using cooperative vehicle-infrastructure systems to collect and exchange energy-relevant data between vehicles and roadside systems, to improve the preview of the traffic situation ahead in order to determine the most economical route or way of driving.
Safer	3	Systems aiming to support the driver to operate the vehicle in a most energy efficient way typically aim to reduce the frequency of hard accelerations and hard brakings. Eco-driving oriented driver support system may also include speed alert functionality which has clearly positive impacts on safety of road users (for summary of studies on speed alert, see http://www.imobility-effects-database.org). Another example could be to give drivers advice for their speed adjustment for helping in the merging of the traffic flows in highway ramps. Eco-

Service: Eco-driving	Magnitude of impact	Description of the impact
		driving services potentially have a positive impact on safety which could reach a national level.
More Accessible	1	The eco-driving services could help in make the city more accessible. These systems, in fact, use the information from different sources (e.g. road side units, traffic management centers, GIS systems containing attributes needed for eco-driving, and also from other vehicles) to determine the best route, the most efficient driving strategy and the optimal traffic management.
Total impact	1 / 2	The five mobility policy dimensions are addressed to the achievements of a sustainable urban system. The span of impacts is inherently confined into the urban dimensions, possibly regional by taking into consideration systematic commuting trips. By looking at the effectiveness of the bundle on each individual policy pillar it must be pointed out that all of them are positively affected by the delivery of the services; therefore, by promoting the adoption and the deployment of these services to all European urbanized areas, the positive impacts at European scale on the sustainable mobility can be very high.

Legend:

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1.9.5 Technological impacts

Service: Eco-driving	Magnitude of impact	Description of the impact
Innovation	4	Considerable amount of innovation is required to combine the various features of

Service: Eco-driving	Magnitude of impact	Description of the impact
		the service, which include mobility, data storage and processing, real-time travel support and monitoring the condition of the vehicle. These will lead to multi-functional in-vehicle system and data management service, which is will be challenges for service integrators.
Technological breakthrough	4	There will be new service available at the European level that addresses multiple policy goals of the EU. This will be, in spite of combining mainly existing technologies, a major technology advancement.
Research competitiveness	3	Service development will startby focusing on providing solutions that work in the national context, where language, local technology standards and user preferences define the solutions technical specifications. The first service cases will most likely utilize architectures, technologies and components developed at European level as demonstrated in the eCoMove project (Mathias, Vreeswijk and van Koningsbruggen 2011).
Standards agreements	4	Availability of data for the system and the ways in which data are collected from and provided to service users must be agreed on at the European level in order to ensure the maximum coverage of the system and the principles of using the system across national borders.
Industrial leadership	3	Cooperative eco-driving services are being standardised by ETSI, and at least some components and interface will be based on existing European standards. Support for eco-driving applications will be implemented as a part of ICT infrastructure intended for a set of ITS applications. The support for eco-driving applications will have a positive impact on the competitive position of European system and components suppliers.
Technological leadership	4	Development of technical solutions and systems providing services related to eco-driving will take place at national and European level. Some level of interoperability between national solutions will be required. Development taking place

Service: Eco-driving	Magnitude of impact	Description of the impact
		at European level will offer opportunities to re-use the solution developed and to benefit from economies of scale. Eco-driving oriented driver support and energy efficient traffic control are currently active research topics.
Integration	4	The availability of the service will provide greater integration of various services that at presently do not offer all the features that are envisaged to appear in the new service. The integration is linked to data, user interface and linking of physical infrastructure used to data infrastructure supporting the service.
Knowledge transfer	4	The service will require transfer of knowledge between different ecosystems and across national borders. The integration of applications from various member states and the interface design in a way that takes into consideration various features of the system will be a massive operation.
Infrastructure development	4	The service will require smarter infrastructure across Europe that can take into consideration the requirements of the information collection and provision envisaged in the service delivery. Most likely the technology solutions are based on existing mass production components but may also require alteration of the existing physical infrastructure to be fitted.
Mobility of personnel	4	The system will improve the mobility of those already using the transport system but it can potentially create an adverse impact of introducing more users of private vehicles to transport system as the benefits are experienced by also the new users. Mobility impact is expected to be European level, as the system will improve route planning and availability of timely travel information.
Total impact	4	Technological challenges related to the service provision are massive, resulting from availability of the service in all Member States to the data handling and storage. Due to the infrastructure revision needs the actual implementation may become stalled, unless sufficient funds are secured for the

Service: Eco-driving	Magnitude of impact	Description of the impact
		required investments.

Legend:

0 = no impact
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5 = potential impact, reaching global level

1.10 Service: Dynamic last mile delivery

1.10.1 Description

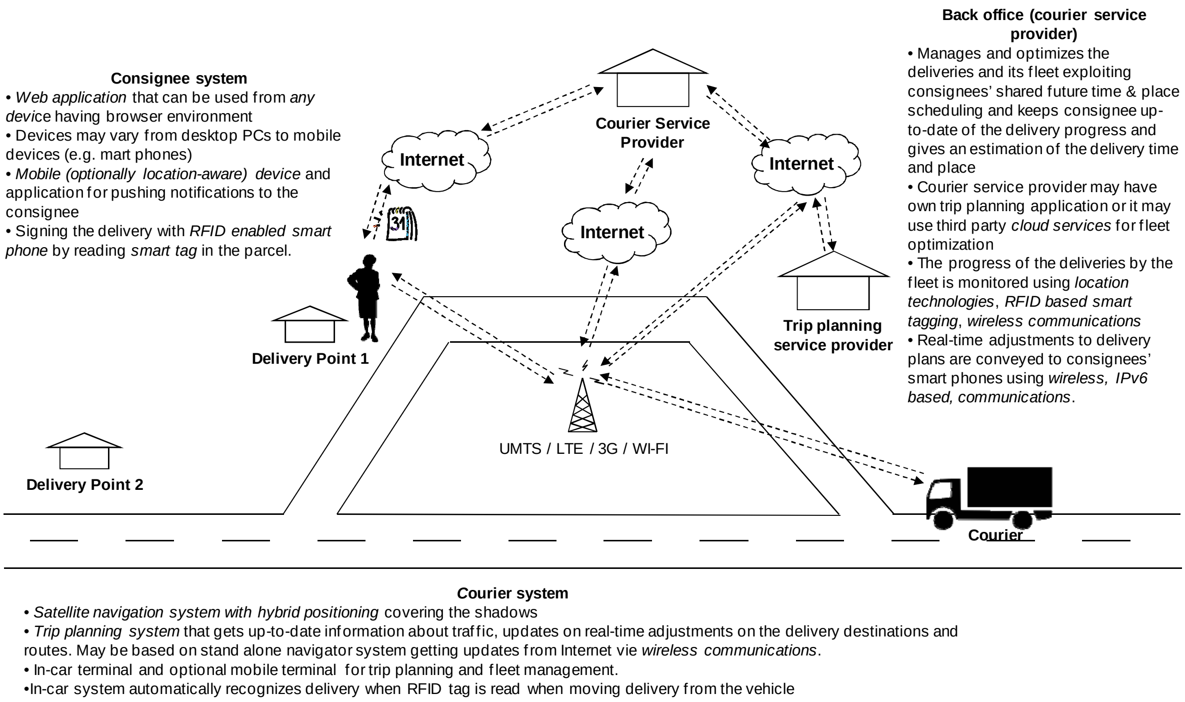

Figure 50: Dynamic last mile delivery concept.

(Source: Pihjalamaa et al. 2012)

1.10.2 Economic impacts

Service: Dynamic last mile delivery	Magnitude of impact	Description of the impact
Growth	1	Service can improve the logistics and efficiency within the immediate

Service: Dynamic last mile delivery	Magnitude of impact	Description of the impact
		surroundings and the faster delivery can create growth impacts at city level, as the deliveries become more rapid.
Economic competitiveness	1	The service availability can improve the small business operations and give competitive edge to the companies that can provide or take advantage from the service.
Economic welfare	1	Those companies that can benefit from the service are likely to experience welfare gains but due to the relatively marginal impact of the last mile delivery on the whole logistics chain these impacts are likely to remain at city level.
Investment	1	The main elements of the service already exist and some investments to support the satellite navigation system may be required. The use of the service itself is not expected to generate major investments, with the exception of some software required to track the delivery addresses.
Market share	2	Last mile deliveries are likely to be provided by companies that will specialize in this service model, either as a part of the broader logistics chain or as a separate niche market. However, the main impact is likely to appear in the city and regional context as the service can be provided by multiple entities with a country.
Overall impact	1	Major impacts are not foreseen from this service, it mainly addresses a segment of freight transport that will improve service level experienced by the end users of logistics services.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level

3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.10.3 Social impacts

Service: Dynamic last mile delivery	**Magnitude of impact**	**Description of the impact**
Cohesion	0	The service is not considered to have cohesion impacts on people as it mainly deals with the freight transport.
Health	0	No health impacts are envisaged as the service does not address people's mobility.
Employment	1	Some additional jobs may be created to manage the service but these are likely to remain at city level.
Quality of life	1	The availability of this service will improve the people's day-to-day life by allowing greater flexibility in receiving deliveries. These impacts will be city level due to the nature of the service.
Service level	1	In relation to the improvements in quality of life, the service level will improve considerably and make delivery business more smooth and customer friendly.
Greenhouse gas emissions	0	The volume of delivery business in the transport system is relatively small and it is not foreseen that major reductions in emission will take place even within city limits.
Overall impact	1	Social impacts of the service are very minimal as the service is targeted to freight and logistics, where the users of the service do not interact with other users.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.10.4 Policy impacts

Service: Dynamic last mile delivery	Magnitude of impact	Description of the impact
More Fluid	1	Dynamic last mile delivery service offers greater flexibility on the time and location where the delivery may take place. It also reduces the number of unsuccessful delivery attempts. Reduction in the number of vehicle kilometres driven in congested traffic conditions can be expected. However, the impact on fluency of traffic will be small and it will be realized only within urban areas.
Greener	2	The optimization of flows of goods and so last mile freight distribution within and into urban conglomerates can improve the environmental quality of urban surroundings. This can be achieved, for instance, by applying trip planning systems and fleets monitoring through RFID based smart tagging.
Smarter	1	The application of ICT systems for trip planning and fleet management definitely has an impact on the smartness level of the city.
Safer	1	The system is not assumed to have direct impacts on safety. However, advanced fleet management systems connected with on-board computers gather a set of information that can also be a valuable tool to enhance safety on the urban road network and to promote safer driver behaviour within the logistic company using the system.
More Accessible	1	The dynamic negotiation of the deliveries allows the final consignee to have a better access to the service in terms of quality, efficiency and availability.

Service: Dynamic last mile delivery	Magnitude of impact	Description of the impact
Total impact	1	The five mobility policy dimensions are addressed to the achievements of a sustainable urban system. The span of impacts is inherently confined into the urban dimensions. By looking at the effectiveness of the bundle on each individual policy pillar it must be pointed out that all of them are positively affected by the delivery of the services; therefore, by promoting the adoption and the deployment of these services to all European urbanized areas, the positive impacts at European scale on the sustainable mobility can be significant.

Legend:

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5 = potential impact, reaching global level

1.10.5 Technological impacts

Service: Dynamic last mile delivery	Magnitude of impact	Description of the impact
Innovation	0	There is no major innovation required in providing the described service.
Technological breakthrough	0	No major technology advancement is required for provision of this service.
Research competitiveness	0	The service does not require significant development of new research or products so there will be no impact.
Standards agreements	0	No standards are needed to be agreed in order to provide the service; applications can be developed with no restrictions or instructions.
Industrial leadership	0	There is no foreseen leadership developing for this service as the applications can location or company-specific.
Technological leadership	0	Similarly to industry leadership, now major technology provider is foreseen as a

Service: Dynamic last mile delivery	Magnitude of impact	Description of the impact
		requirement, more likely individual solutions providers will emerge.
Integration	1	Technology integration is needed at city level to combine information of locations of service users and deliveries.
Knowledge transfer	0	No knowledge transfer is expected to take place.
Infrastructure development	1	Some additional developments in the infrastructure may be required, in particular related to the satellite based monitoring of vehicles.
Mobility of personnel	0	Due to the nature of the service no mobility impacts will be foreseen.
Total impact	1	The service will not require major technological advancements, and will utilise existing technologies.

Legend:

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10 Bundle: Urban Traffic Management Services

1.11 Service: Cooperative traffic signal control

1.11.1 Description

Figure 51: Cooperative traffic signal control concept.

(Source: Pihjalamaa et al. 2012)

1.11.2 Economic impacts

Service: Cooperative traffic signal control	**Magnitude of impact**	**Description of the impact**
Growth	0	No major growth impact is foreseen to result from the service.
Economic competitiveness	0	There are no direct impacts on competitiveness from this service.
Economic welfare	1	The system is expected to have a positive impact on economic welfare on city level. The impact is related to shorter average travel times experienced by road users. However, the impact on average travel times is likely to be small and it will depend on the performance of traffic control

Back office system in T
• Back office collects the traffic data from RSUs
Internet of Things technologies (including M2M
• In addition to management of RSUs and vehic
GIS databases, massive real time spatio-tempo

Service: Cooperative traffic signal control	Magnitude of impact	Description of the impact
		systems and the functionalities they provided before the system was implemented.
Investment	1	Most of the investment impact will result from data management linked to the fleet management with the traffic signal control system. These investments will take place in cities where the system is being implemented.
Market share	1	Most likely a single company will emerge to provide the services within a city as the market will be fragmented due to the limitation of the system to cover mainly major cities in Europe.
Overall impact	1	The service will not generate significant economic impacts outside the immediate surroundings of a city, even in this context the overall impact is limited.

Legend:

0 = no impact
1 = potential impact, within the city limit
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5 = potential impact, reaching global level

1.11.3 Social impacts

Service: Cooperative traffic signal control	Magnitude of impact	Description of the impact
Cohesion	0	There is no cohesion impact associated with this service.
Health	1	The system aims to reduce the number of accidents which happen at signalised intersections in urban environments. The system is expected to have a positive impact on health where it is implemented
Employment	0	No major employment gains will result from the adoption of this service.

Service: Cooperative traffic signal control	Magnitude of impact	Description of the impact
Quality of life	1	In the cities people will find the driving more pleasant and enjoyable if they adjust their travel to suggested speeds and green light patterns.
Service level	1	New service can improve in particular driving during off-peak hours when green lights can be made more user-friendly according to vehicles on the streets.
Greenhouse gas emissions	1	Minor impacts on emissions can be observed as waiting times at traffic lights are likely to shorten and the number of stops and accelerations will likely be reduced.
Overall impact	1	The service will have limited social impacts, mainly within the implementing city through improvements in mobility and service level.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.11.4 Policy impacts

Service: Cooperative traffic signal control	Magnitude of impact	Description of the impact
More Fluid	1	The traffic congestion level will certainly decrease by introducing cooperative systems for decentralized traffic signal control. These systems can optimize traffic flows system and so reduce total delay time of the urban network.
Greener	1	When implemented, the system will reduce the number of stops and accelerations at intersections in urban environment. The system has also potential to reduce the number of vehicle kilometres driven in queuing and slowly moving traffic. This will have a positive effect on emissions and

Service: Cooperative traffic signal control	Magnitude of impact	Description of the impact
		energy consumption.
Smarter	1	Cooperative traffic signal control systems by definition increase the smartness of the city where they work.
Safer	1	Effects of signal timing on safety can be seen in the Detection Control System. This real-time adaptive control application is effective at improving the relative safety of an intersection and so increasing safety at city level.
More Accessible	1	Efficiently managing the traffic on the network through cooperative systems applied to traffic signal control can improves accessibility at city level in terms of quality of access that people and business have to the urban mobility system.
Total impact	1	The five mobility policy dimensions are addressed to the achievements of a sustainable urban system. The span of impacts is inherently confined into the urban dimensions. By looking at the effectiveness of the bundle on each individual policy pillar it must be pointed out that all of them are positively affected by the delivery of the services; therefore, by promoting the adoption and the deployment of these services to all European urbanized areas, the positive impacts at European scale on the sustainable mobility can be noteworthy.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.11.5 Technological impacts

Service: Cooperative traffic signal control	Magnitude of impact	Description of the impact
Innovation	1	Innovation takes place within the city

Service: Cooperative traffic signal control	Magnitude of impact	Description of the impact
		context where the new and improved traffic light guidance will help users to optimize their travel patterns.
Technological breakthrough	0	No major new technologies will be required to introduce the service.
Research competitiveness	1	Utilization of a vast number of data sources in real-time network level traffic optimization of urban traffic is a topic still under research. Solutions to this problem still have novelty value and relevance as research topics.
Standards agreements	0	No agreements on standards are required as the service is very much fixed to its immediate surroundings.
Industrial leadership	1	Service can be designed and implemented locally, even through the utilisation of local SME sector to provide the required technologies.
Technological leadership	1	No major technologies will need to emerge nor should the service be produced (necessarily) by larger companies as the solutions can be also very localised and therefore provided by companies for which these markets are more attractive than for the bigger industry players.
Integration	1	Integration of vehicle data and traffic light management will take place at the city level.
Knowledge transfer	0	No knowledge transfer is foreseen to take place in context of this service.
Infrastructure development	1	Within cities the need to integrate fleet data with traffic light management system creates the demand for new infrastructure development, but this is basically based on upgrading the existing system to be technically compatible with the data transfer and on-time management of system.
Mobility of personnel	1	People's mobility within cities will be improved due to less waiting times and better flow of traffic. Again, these improvements may have adverse incentives for service users to adopt use of private vehicles as it will become more attractive.

Service: Cooperative traffic signal control	Magnitude of impact	Description of the impact
Total impact	1	Technological requirements are low for this service and this results in a low overall score, where impacts are observed they are within city limits.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.12 Service: Speed management

1.12.1 Description

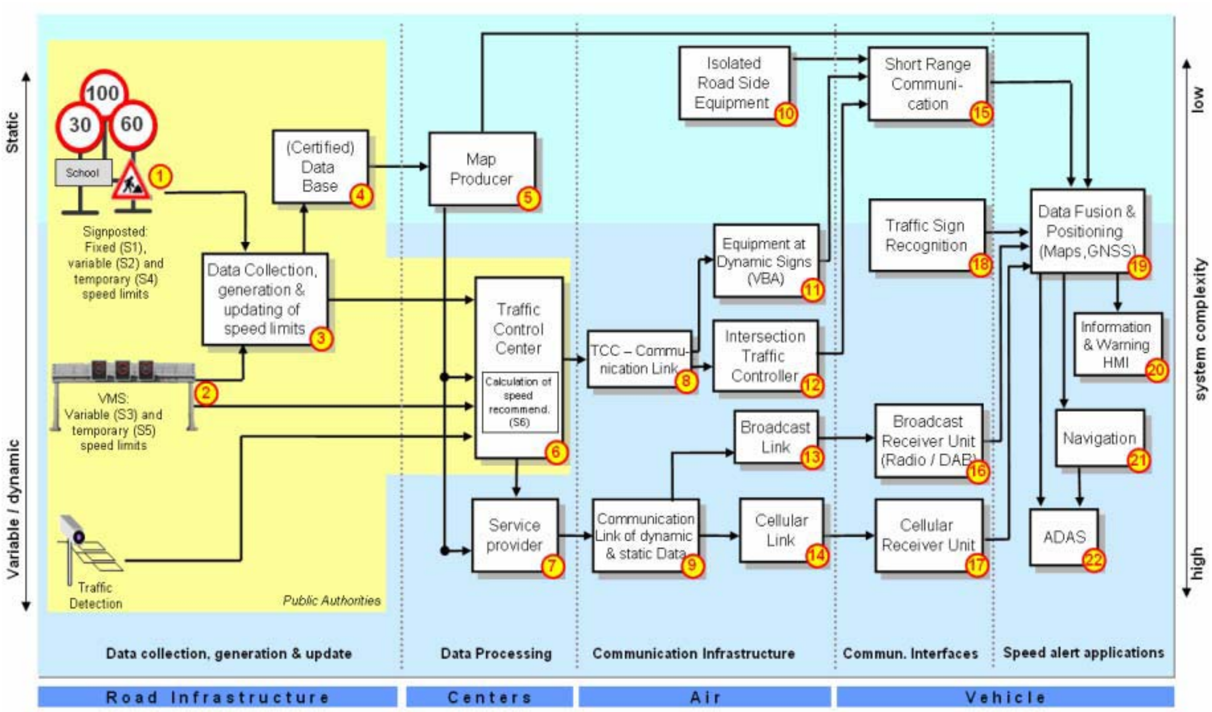

Figure 52: Speed management concept.

(Source: Pihjalamaa et al. 2012)

1.12.2 Economic impacts

Service: Speed management	**Magnitude of impact**	**Description of the impact**
Growth	2	Potential growth impacts are created by the better operation of transport system, which mainly affects the daily commuting traffic in regional and city context. The growth is a result of a small reduction of travel times (http://www.imobility-effects-database.org) and preparedness to address the impact of weather and other factors on the operability of the transport system.
Economic competitiveness	0	No major impact on economic competitiveness is foreseen.
Economic welfare	2	Improved safety of road users will have a positive effect on economic welfare

Service: Speed management	Magnitude of impact	Description of the impact
		of society, impacting the commuting traffic within cities and the surrounding region. The system has been estimated to be socio-economically profitable in an analysis carried out for one EU member state (Lai, Carsten, Tate 2012). The magnitude of the effect will depend on the type of ISA implemented and the deployment scenario.
Investment	3	Investment are needed to provide the signalling system, which will boost the development of durable and low costs variable speed signs required to replace the current signs.
Market share	3	Speed limit databases will be established at national level (ROSATTE implementation platform). It is likely that management of speed limit data at national level will be carried out by a single company. In-vehicle systems integrated in the vehicle will be developed at the European or global level.
Overall impact	2 / 3	The service has potential to increase investments to technologies that enable use of speed management as a means to controlling the traffic. This means major investments to replace current signals and also cabling and other supporting infrastructure.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.12.3 Social impacts

Service: Speed management	Magnitude of impact	Description of the impact

Service: Speed management	Magnitude of impact	Description of the impact
Cohesion	0	The nature of the service does not lead to any cohesion impacts.
Health	2	Health impacts result from better control of speed on roads, resulting in less accidents and injuries, which will affect in particular the commuting travel in the city and regional context.
Employment	0	There are no employment impacts associated with the service.
Quality of life	4	The service will improve quality of life in Europe as the speed management becomes more linked to actual conditions and less static as is the present situation. People will also have better chance to adjust their driving and to take necessary precautions against changing driving conditions.
Service level	4	The service level of speed management will improve significantly and can lead to reduction in accidents and more predictable travel times. These new features will benefit in particular frequent travellers but will also provide comfort to those who are less frequent travellers or not familiar with local roads and their conditions.
Greenhouse gas emissions	2	Mandatory speed alert system would reduce considerably emissions and energy consumption. The effects of a voluntary system are likely to be smaller and the evidence on their impacts in areas with low speed limits is partly contradictory (http://www.imobility-effects-database.org).
Overall impact	2 / 4	The major impact of the service will be the improved service level, as the transport system users can better adjust their speeds to external factors than simply relying on their own situation analysis.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level

4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.12.4 Policy impacts

Service: Speed management	Magnitude of impact	Description of the impact
More Fluid	0	Impacts of speed management will depend on the number of vehicles equipped with the system. When the share of equipped vehicles above a certain threshold, the system will result in a more homogenous and smoother traffic flow. When only a small fraction of drivers use the system, the system may increase the frequency of overtaking situations.
Greener	3	Mandatory ISA (intelligent speed adaptation) will reduce considerably emissions and energy consumption. For voluntary ISA, the impacts are smaller and evidence on impacts is partly contradictory for areas with low speed limits (Andersson 2009; Carslaw et al. 2009).
Smarter	3	The Intelligent Speed Adaptation (ISA) system is a good example of ICT technologies applied to vehicles for increasing the safety aspect of urban mobility. The system in fact enables the vehicle to 'know' the relevant speed limit from an on-board and updateable database of speed limits, and a Global Positioning Satellite (GPS) system advising where the vehicle is located. The system then provides feedback to the driver about whether current speed exceeds that limit.
Safer	4	The main scope of speed management services is to increase the level of road safety. Speed alert provided to the driver has been estimated to reduce the number of fatalities in EU27 by 4.5-12.6% and injuries by 2.6-9.5% if all vehicles were equipped with the system (Wilmink et al. 2008).
More Accessible	0	The system is not expected to have any significant impact of accessibility of services or locations.

Service: Speed management	Magnitude of impact	Description of the impact
Total impact	3	All the five mobility policy dimensions are addressed to the achievements of a sustainable urban system. The span of impacts is inherently confined into the urban dimensions, except for smartness and safety which can get to a national and European framework respectively. Of course by looking at the effectiveness of the bundle on each individual policy pillar it must be pointed out that all of them are positively affected by the delivery of the services; therefore, by promoting the adoption and the deployment of these services to all European urbanized areas, the positive impacts at European scale on the sustainable mobility can be very high for all the five pillars.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.12.5 Technological impacts

Service: Speed management	Magnitude of impact	Description of the impact
Innovation	0	There is no major innovation involved in the service, the major elements are already tested and in use in some pilot regions.
Technological breakthrough	3	To upgrade the service to national level management from testing sites requires development of low-cost signs that will replace the existing ones and where the transfer of signal works in all conditions, when a change to existing speed limit shown is required.
Research competitiveness	0	No impact is expected on research competitiveness as most of the technologies required are already tested and piloted by potential service providers.

Service: Speed management	Magnitude of impact	Description of the impact
Standards agreements	3	Current status and management of speed limit data in Europe has been studied by the ROSATTE project (ERTICO 2012). Rosatte implementation platform is being established (Flament 2012) to utilize the work carried out in ROSATTE and to support data flow from national road administrations to providers of digital maps.
Industrial leadership	3	Systems used to manage speed limit implementation will mostly be implemented on national level.
Technological leadership	3	National level service providers are likely to generate the leadership that is required to produce integrated systems. These service providers can also provide the similar service to other countries and provide more broad solutions.
Integration	3	National level service providers will be responsible for integrating data from various infrastructure managers into a common database at national level. Efforts to integrate speed limit data into existing digital maps are being made by digital map providers and the work is supported by ROSATTE implementation platform.
Knowledge transfer	0	No knowledge transfer is considered to be associated with the service.
Infrastructure development	3	Infrastructure development needs to address the speed management needs in various parts of the Europe. At present, most member states have no national level speed limit database, and investment in new ICT infrastructure will be required.
Mobility of personnel	1	The effects of speed alert system on travel time are likely to be negligible on urban roads because delays at intersections constitute much of the travel time (Wilmink et al. 2008). Therefore, the impacts of the system on mobility are likely to be very limited.
Total impact	3	The service has mixed impacts, which results in average score perhaps misleadingly pointing the regional level impacts. Some of the impacts will be experienced at the European level whereas in many cases there

Service: Speed management	Magnitude of impact	Description of the impact
		are no technological impacts at all.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.13 Service: Predictive smart parking

1.13.1 Description

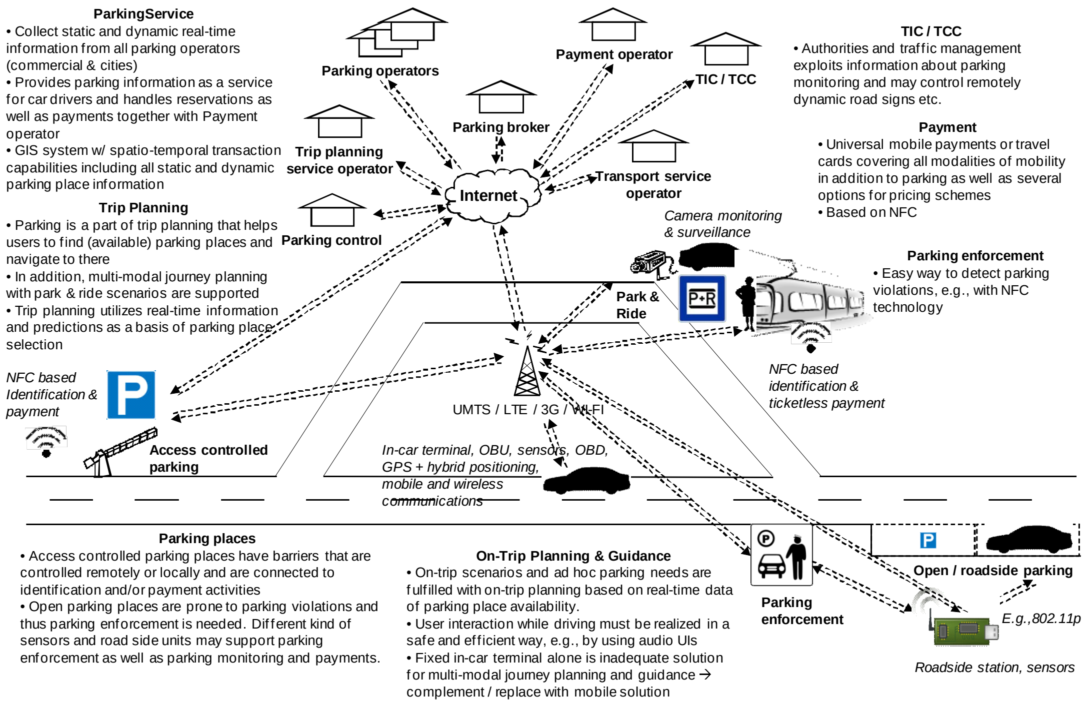

Figure 53: Dynamic and predictive parking concept.

(Source: Pihjalamaa et al. 2012)

1.13.2 Economic impacts

Service: Dynamic and predictive parking	Magnitude of impact	Description of the impact
Growth	1	The growth impacts will materialise through gains in productive time due to less time spent in search for parking space; these are calculated as time savings (minutes per driver per day); additional impact is the increased revenue of the cities from parking fees and probably lower cost of enforcement; however, even when added up the impacts remain local and possibilities to make the system European standard depend on interface design and ability to convert locally available data to solutions that are usable through multiple types of interfaces (including language conversions). There is potential to foster innovation in the field of

Service: Dynamic and predictive parking	Magnitude of impact	Description of the impact
		ITS services associated to smart parking. This would in turn contribute to global growth and go beyond local level impacts.
Economic competitiveness	1	In terms of the competitiveness, the savings in time and the related increase in productivity are considered minor. Impacts can improve dynamics but do not have sizeable impacts to be detected when comparing productivity of cities or productivity in Europe against other regions.
Economic welfare	1	The users of the city parking facilities will be better off, but again the impacts do not result in gains that can in terms of magnitude or coverage reach significant impact at the European or even national level. There are gains related to quality of life through the parking service, which are due to less congestion but there is no direct welfare gain associated with the service.
Investment	1	Significant investment in physical or ICT infrastructure will not be required to implement the service except sensing and detection systems such as cameras or other types of sensors.
Market share	4	Companies that provide integrated services for the parking are likely to have a great market share in Europe as a whole, when they have demonstrated the functionality of the systems through piloting. These companies will most likely provide a limited number of similar solutions to the markets, which can be tailored to each city and have some level of interoperability between cities and technologies.
Overall impact	1	Due to the fact that most of the impacts will be local and the benefits, although covering a large volume of users, will remain modest the overall impact of the solutions will remain limited. This can be enhanced by coupling parking solutions with other traffic management applications.

Legend:

0 = no impact
1 = potential impact, within the city limit

2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.13.3 Social impacts

Service: Dynamic and predictive parking	Magnitude of impact	Description of the impact
Cohesion	0	The application does not address cohesion directly.
Health	1	The health impact will be of local nature, mainly resulting from better local air quality due to less emissions resulting from reduced search time for available parking. Obviously in major cities these impacts can affect large populations so the magnitude depends on the city.
Employment	1	The system and its maintenance, as well as effective monitoring will create new jobs, but these are mainly at local level for people needed to manage the system. On the other hand fewer jobs needed for manual onsite enforcement. As technologies are already available from industries there are no major additional employment gains in industries.
Quality of life	3	The application can improve the quality of life as people spend less time in search of parking space and find the system less stressful than situation before. Impact on congestion will also be significant and affects cities and citizens. These impacts can be considered national level, the availability of dynamic and predictive parking service will improve moving around in other cities as well.
Service level	4	Overall, in Europe the parking system will become more interactive and will considerably improve the management of parking services for operators. Users can benefit from the new services.
Greenhouse gas emissions	3	Depending on the volume of traffic in cities and countries, the service can potentially reduce emissions significantly, also due to possibilities to promote electric and hybrid solutions through preferred parking

Service: Dynamic and predictive parking	Magnitude of impact	Description of the impact
		solutions.
Overall impact	1 / 3	Social impacts are two-fold, creating mainly broad impacts through the services' ability to serve better urban parking demand.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.13.4 Policy level impacts

Service: Dynamic and predictive parking	Magnitude of impact	Description of the impact
More Fluid	1	Well in advance, up-to-date and everywhere information about parking space availability will positively impact the fluency of urban traffic. The drivers, in fact, will be informed in good time on the current occupancy levels of parking lots and car parks, allowing them to plan their route accordingly and reach their destination in the shortest time possible.
Greener	1	By reducing the length of time a vehicle circulates on urban streets or in a car park, emissions and noise levels will be reduced and so requirements on better air quality and noise abatement can be met. However, the impact is realised only in parking facilities and city centres with limited availability of parking.
Smarter	3	Traffic and travel data processing can provide information, assistance and dynamic control of transport to drivers and network managers. ICT technologies to be used for enhancing parking guidance systems and integrating them in higher level traffic systems can improve the management efficiency of urban mobility and the interoperability level towards smarter urban transport.

Service: Dynamic and predictive parking	Magnitude of impact	Description of the impact
Safer	0	The system is not expected to have significant impacts on safety of road users.
More Accessible	2	These systems will surely increase the level of accessibility from the view point of the quality of access that people and business have to the urban mobility system, made up of infrastructure and services.
Overall impact	1 / 2	The five mobility policy dimensions are addressed to the achievements of a sustainable urban system. The span of impacts is inherently confined into the urban dimensions, possibly regional by taking into consideration systematic commuting trips. By looking at the effectiveness of the bundle on each individual policy pillar it must be pointed out that all of them except safety are positively affected by the delivery of the services; therefore, by promoting the adoption and the deployment of these services to all European urbanized areas, the positive impacts at European scale on the sustainable mobility can be very high.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.13.5 Technological impacts

Service: Dynamic and predictive parking	Magnitude of impact	Description of the impact
Innovation	3	Although not an entirely new concept, and while utilising mainly existing technologies the innovation lies in the potential to bring the solutions together into an integrated service that can benefit commuter and leisure traffic, including tourism, provided that the user interface is designed to work in

Service: Dynamic and predictive parking	Magnitude of impact	Description of the impact
		non-local equipment and platforms as well. The first solutions to be available will be realised at national or regional level.
Technological breakthrough	1	Only when considered to change the existing services available in cities for parking can the application be considered to have a technological advancement at the city level. Internet of things, real-time allocation of parking spots is a challenge, which can be solved through private areas, but public areas (road sides) remain difficult to address as the installation of technologies for monitoring and vacancy data is more challenging.
Research competitiveness	1	The selected application within a city will be a result of competitiveness in design and concept development, but at the European level it will be hard to detect changes in research competitiveness.
Standards agreements	4	The potential to have agreement on the interoperability of various city level applications at the European level to improve citizenship & tourism and other usage can lead to standards, with regards to functions of the applications (payment methods, user interfaces, signalling etc.). In particular the presentation of city infrastructure based on a common standardized presentation is crucial in setting a common platform for applications.
Industrial leadership	3	At national level there are likely to emerge companies that provide concept development and tailor-made applications that suit the local conditions, as the market will be attractive when the customer base is larger. Naturally major cities offer a lucrative market but it is more likely that companies would choose to provide applications to a country as a whole.
Technological leadership	4	European level coverage will result in leadership which is defined by data use in information applications. Key is to build user interfaces that enable use of system independent of location or language, resulting in greater interoperability.

Service: Dynamic and predictive parking	Magnitude of impact	Description of the impact
Integration	4	Systems and applications will enhance the mobility of people, interoperability of various actors (public sector, companies, users etc.) and also generate systems level integration, which can be best achieved through interactive user applications.
Knowledge transfer	3	Impact will be limited in some cases, mostly through training of local staff for practical management of applications within a city. Based on national level operators' experiences, the solutions can be taken to other locations with appropriate modifications.
Infrastructure development	1	The system will be realised by combining existing physical and ICT infrastructure with new technologies. Also, reduction in the need for parking space can in the future change the existing infrastructure.
Mobility of personnel	2	Better information on parking can result in changes in commuter habits, which can be an inverse impact in terms of increasing the share of trips done by private vehicles. However, if the goal is to reduce private car use (also dynamic) pricing can be used to control traffic volumes and choice of transport mode (keeping in mind equality considerations).
Total impact	1 / 4	The total impact of the parking system is a result of low impact caused by city level solutions and of high impact caused by EU-level standardisation and applications that have cross-border implications and result in better predictability in travel within and to cities. It needs to be acknowledged that the impact of less congestion as a result of dynamic and predictive parking will lead to impacts observable at the city level when it comes to congestion or emissions reductions, which are part of the social and economic impacts. Taking into consideration that cities are nodes in TEN-T networks will increase the value of smooth parking from the European perspective.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

11 Bundle: Booking and payment

1.14 Service: Mobile payment

1.14.1 Description

Figure 54: Mobile payment concept.

(Source: Pihjalamaa et al. 2012)

1.14.2 Economic impacts

Service: Mobile payment	Magnitude of impact	Description of the impact
Growth	0	The payment system does not have any growth impacts as it basically aids the current systems in administrating the payment of various services.
Economic competitiveness	0	There are no impacts on competitiveness from this service as the service provided will only marginally change current processes.
Economic welfare	0	No welfare gains are envisaged to take place from the use of this service.
Investment	0	No major investments are needed to provide the service and it is not foreseen that it

Service: Mobile payment	Magnitude of impact	Description of the impact
		would generate any investments.
Market share	4	It is likely that the service will be provided at the European level by one or more companies as is the situation at present with other similar services offered by financial institutions.
Overall impact	4	Economic impacts are limited and linked to the service provider's role in the European markets.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.14.3 Social impacts

Service: Mobile payment	Magnitude of impact	Description of the impact
Cohesion	0	Due to the nature of the service there will be no cohesion impacts.
Health	0	Due to the nature of the service there will be no health impacts.
Employment	0	The service provision will not require additional resources in terms of staffing and it will not generate any additional jobs either.
Quality of life	1	The availability of better payment services will most likely improve the daily activities of service users but these impacts will be limited in the immediate surroundings at the city level.
Service level	4	Users can better benefit from existing technologies in their day-to-day travel and the service is likely to be available throughout Europe, which will benefit travellers that utilise public transport anywhere where the system is available.
Greenhouse gas	0	The service provided has no impact on

Service: Mobile payment	Magnitude of impact	Description of the impact
emissions		emissions.
Overall impact	1 / 4	Social impacts, apart from improved service level, are likely to remain small. Payment service is not considered to affect the social interaction as such.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.14.4 Policy impacts

Service: Mobile Payment	Magnitude of impact	Description of the impact
More Fluid	0	Mobile payment services do not have any impacts on the level of urban congestion.
Greener	0	Mobile payment services do not have any impacts on the level of environmental issues.
Smarter	0	Mobile payment services do not have any impacts on transport smartness.
Safer	0	Mobile payment services do not have any impacts on safety.
More Accessible	0	Mobile payment services do not have any impacts on the level of transport accessibility.
Total impact	0	This service bundle does not have any significant impacts from the policy view point.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.14.5 Technological impacts

Service: Mobile payment	Magnitude of impact	Description of the impact
Innovation	0	There is no major innovation in the service provision as it is based on existing technologies.
Technological breakthrough	0	There is no major technological breakthrough required to provide this service.
Research competitiveness	0	There is no research competitiveness involved in the provision of the service.
Standards agreements	4	Regarding payments and data transfer there needs to be agreement at the EU level of the format of data and privacy of users of the service.
Industrial leadership	4	It is likely that one or more EU level or global service providers will be responsible for offering the service to clients to have sufficient geographical coverage and client base.
Technological leadership	4	The technologies for payment management are likely to exist at the European level to give a sufficient client base for the broad-based use. These service providers can operate similar payment systems in other markets as well.
Integration	0	The service does not require particular technology integration.
Knowledge transfer	0	Due to the nature of the service no knowledge transfer is expected to take place.
Infrastructure development	0	Due to the nature of the service no infrastructure development is foreseen to take place.
Mobility of personnel	0	Due to the nature of the service no mobility impacts are foreseen.
Total impact	4	The main technological impacts are connected to the service provision, which in many ways is a new application of the existing payment technologies and is most likely benefiting those companies that at present offer similar services already in other market segments.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.15 Service: Mobile ticketing

1.15.1 Description

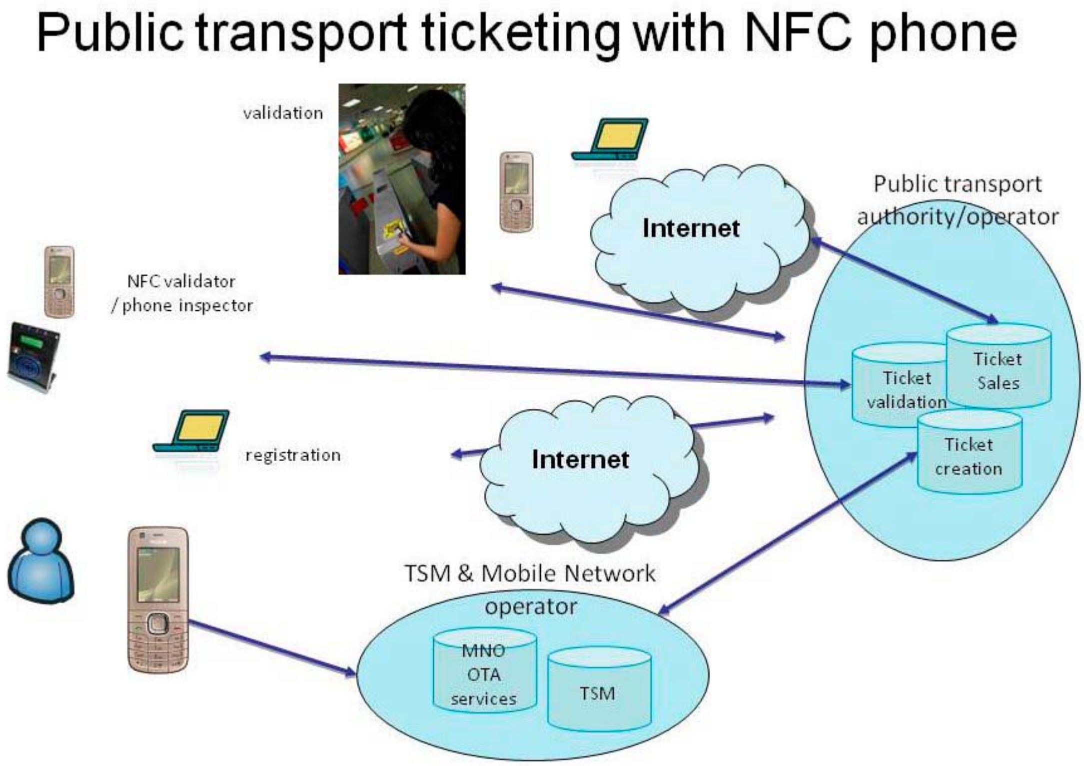

Figure 55: Mobile ticketing concept.

(Source: Pihjalamaa et al. 2012)

1.15.2 Economic impacts

Service: Mobile ticketing	Magnitude of impact	Description of the impact
Growth	0	The service does not have growth impacts. It is focusing on efficiency and alternatives in payment of public transport services.
Economic competitiveness	0	The service aims to increase the use of public transport by providing alternative payment methods. This does not have a direct impact on competitiveness.
Economic welfare	0	Similarly, the service does not generate any welfare impacts.
Investment	0	The service does not require major

Service: Mobile ticketing	Magnitude of impact	Description of the impact
		technologies to be implemented. It is not also generating needs for additional investments in supporting services or technologies.
Market share	2	The system is best utilised within cities and at regional level transport. It is likely that a single operator will provide the services within each urban area and surrounding region.
Overall impact	2	Economic impacts are quite limited and relate to market share, which can be seen to increase the utilisation of public transport and therefore giving the operators using the payment system an advantage in competition.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.15.3 Social impacts

Service: Mobile ticketing	Magnitude of impact	Description of the impact
Cohesion	2	The availability of better ticketing systems will have a minor positive impact on the use of public transport in city and regional context. In other words, easy to use and effectively operating ticketing system is in essential part of public transport service seen attractive by travellers. Particularly commuters and those using public transport as their main mode of transport will benefit from the service.
Health	2	Using public transport is likely to increase people's use of light traffic and therefore to improve the health situation in the context of the transport system use.
Employment	0	The nature of the service does not require major staff and therefore no real

Service: Mobile ticketing	Magnitude of impact	Description of the impact
		employment impacts can be foreseen.
Quality of life	2	The availability of more flexible ticket payment methods is likely to benefit people who are using the public transport or will now have incentives to do so.
Service level	2	The available of more flexible ticket payment will positively impact the immediate surroundings in which public transport is used, the city and regional commuting traffic where the volume and frequency of service make the system meaningful.
Greenhouse gas emissions	2	The shift of passengers to public transport use is likely to reduce emissions, however these impacts depend on the volume of passengers shifting from use of private vehicle and are at best of regional magnitude. Easy to use and effectively operating ticketing system is an essential part of public transport service seen attractive by travellers.
Overall impact	2	The social impact is mainly concentrated on the geographical utilisation of the service, which is supporting in particular city and regional travel.

Legend:

0 = no impact
1 = potential impact, within the city limit
2 = potential impact, reaching regional level
3 = potential impact, reaching national level
4 = potential impact, reaching EU level
5 = potential impact, reaching global level

1.15.4 Policy impacts

Service: Mobile ticketing	Magnitude of impact	Description of the impact
More Fluid	1	The NFC based ticketing system has potential to reduce the time needed for boarding at bus or tram stops. This reduces travel times of public transport passengers.
Greener	1	Potentially, by implementing a mobile ticketing system for public transport, a city can increase the number of users and so change the citizens' behaviours towards a less intensive use of private vehicles.
Smarter	2	Mobile ticketing definitely has an impact that could reach the regional level from the view point of city smartness. The service, in fact, by using ICT systems such as barcodes and contact less RFID integrated circuits or Near Field Communication (NFC) systems will enhance the 'intelligence' of urban environment.
Safer	0	The service is not expected to have any impacts on safety..
More Accessible	2	Mobile ticketing can enhance the integration of different transport modes in a metropolitan area by letting use just one ticket. For this reason the service will definitely have a regional effect on accessibility of public transport.
Total impact	1 / 2	Except for safety, the other four mobility policy dimensions are addressed to the achievements of a sustainable urban system. The span of impacts is inherently confined into the urban dimensions, possibly regional by taking into consideration systematic commuting trips. By looking at the effectiveness of the bundle on each of the four policy pillars, it must be pointed out that all of them are positively affected by the delivery of the services; therefore, by promoting the adoption and the deployment of these services to all European urbanized areas, the positive impacts at European scale on the sustainable mobility can be noteworthy.

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1.15.5 Technological impacts

Service: Mobile ticketing	Magnitude of impact	Description of the impact
Innovation	2	Innovation is limited to the geographical context in which the new service is intended to operate and consists of new ways of integrating the payment system and existing ticketing system for public transport.
Technological breakthrough	0	No new technologies are required, just the integration of existing systems.
Research competitiveness	3	Most likely the service is provided by a national service provider, which has already experience of the similar systems and data management.
Standards agreements	2	Standards are required to integrate the payment systems with ticketing systems but this is again done in the local context within city and the regional commuting system.
Industrial leadership	3	National level entity is likely to manage the similar systems in different cities. This company will integrate various technologies needed.
Technological leadership	3	Same companies that operate systems in the national context are also generating the technical solutions that become utilised in various cities and regions within a country.
Integration	2	Integration is experienced in the city and regional level where ticketing and payment systems are implemented.
Knowledge transfer	0	There is no impact on knowledge transfer in this service.
Infrastructure development	0	No special infrastructure is required as the technology is based on existing hardware and software.

Service: Mobile ticketing	Magnitude of impact	Description of the impact
Mobility of personnel	2	Mobility can be increased in the city and regional context but this is depending on external factors as well such as the service level of public transport system.
Total impact	2 / 3	The technological impacts are mainly limited to the immediate context in which most of the travel utilising the ticketing system takes place, which is within cities and at the regional level. Benefits are reaped by those who travel more frequently and by service providers who can offer their service to interested operators within a region.

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